XVII. 52.

THE PRINCIPLES OF Aſtronomy and Navigation:

OR,

A Clear, Short, yet Full Explanation, of all Circles of the Celeſtial, and Terreſtrial Globes, and of their Uſes; being the whole *Doctrine of the Sphere*, and Hypotheſes to the Phenomena of the *Primum Mobile*.

To which is Added

A Diſcovery of the Secrets of Nature, which are found in the *Mercurial-Weather-Glaſs*, &c.

AS ALSO

A New Propoſal for Buoying up a Ship of any Burden from the Bottom of the Sea.

By *GEORGE SINCLAR*, ſometime Profeſſor of Philoſophy in the Colledge of *GLASGOW*.

Edinburgh, Printed by the Heir of *Andrew Anderſon*, Printer to His moſt Sacred [illegible] Anno D[illegible]



Academiæ Cantabrigiensis
Liber.

1263.19

To the Right Honourable
MAGNUS PRINCE,
Lord Provoſt;

Alexander Brand, *Alexander Simpſon*, *John Morray*, and *William Montgomery*, Baillies; *James Nicolſon* Dean of Gild, *Edward Marjorebanks* Theſaurer; and remanent Members of the Honourable Senate, of the Antient City of *Edinburgh*.

May it pleaſe your Lordſhip, and the Honourable Senate,

IT is neither Ambition, nor Ignorance of your Worth and Merit, which have inclin'd me, to prefix your Names to the Frontiſpiece of this mean Pamphlet, but the ſure experience I have of your encouraging all vertuous Actions and Learning. What I have now in Equity and Reaſon preſented, I humbly deſire the Honourable Senate, may accept favourably. I owe all I have,

and my Self too, to your Devotion and Service. I chuſe rather to be doing ſomewhat Amiſs, than doing Nothing. 'Tis the Widows Mite, which I have ſhelter'd under the Wings of your Protection. If I ſhould endeavour, but to recapitulat, what Sentiments of your Kindneſs I have found, both Time, and my Memory would fail me. None can think, that there is any Deſerving in me, which can be proportionable to thoſe unvaluable Acts of your Bounty. If there be any, I am confident, it is too too ſcanty to Oblige. When I was able to do more, none were found more willing. I endeavoured indeed, according to my Capacity, to contribute my Aſſiſtance for promoving that great and noble Deſign, which was accompliſh'd; for which the Generations to come, ſhall call you Happy, whom you have Enriched, with Refreſhing-Streams of Cooling-Waters, more Advantagious and Uſeful to the City, than the Fruit of the Vine. I cannot ſatisfie all the Obligations to Duty, which ly upon me. The more

more I was inclin'd to offer this Trifle, the more I was overcome with Reaſons perſwading to the contrary. But the uprightneſs of my Intention, to beautify this trivial Subject, with the Splendor, and Glory of your Names, will excuſe the faillings of my Underſtanding. I cannot remunerat the Kindneſs of the Honourable Senate, better, than by Hearty Prayer, that the LORD may give you, the Spirit of Wiſdom, and Government, to Manage the Weighty Affairs of the City, and His Conduct, not only to Guide each one of you, in his particular Calling, but all of you, to the endleſs Fruition of Immortal Life. This I fervently wiſh, while I am

Your Lordſhips and the Councils,

much Obliged Servant,

GEORGE SINCLAR.

TO

TO

TO THE READER.

I *Judge it altogether needleſs to Preface any thing by way of Commendation to the following Tracts. They will (I hope) commend themſelves, to the intelligent Reader. There is firſt,* The Doctrine of the Sphere, *ſo compendiouſly ſet down, that nothing can either be Added, or Subtracted. It is the very Rudiments of* Aſtronomy *and* Navigation, *and of many other* Mathematical Sciences. *By the uſe of the Globes, the whole* Doctrine of the Sphere *may be eaſily comprehended, even by the meaneſt Capacity. The ſecond Tract, is not ſo evident, becauſe more* Phyſical, *and leſs* Mathematical, *but perhaps as ſure. I have ſet down my own Thoughts only, If any Man ſhall offer to ſalve the* Phenomena *better, I ſhall be glad. The third Tract is, a new Invention for* Buoying up of Ships from the Ground of the Sea.

Sea. *This Proposal was made some few Years ago, to try the Invention and Wit of some Notional Men, but though they have plowed with my Heifer, yet were they not able, to find out my Riddle: Nay some of them were so confident to aver, that when this Proposal was made to them,* How to make a Vessel Sail below the Water; *they Replyed, it might be easily resolved by their Analyticks.*

ERRATA.

In the second Tract, Page 28. line 13. for *earthly* read *earthy*. pag. 33. lin. ult. for *Idea* read *Idea*.

THE

THE PRINCIPLES OF Aſtronomy and Navigation.

CHAP. I.

Of the Circles of the Sphere in general.

THE material Sphere, is an Inſtrument, whereby all the Phenomena of the *Primum Mobile*, are moſt eaſily known.

It is compoſed of Ten Circles chiefly, which are, the Equinoctial, the Zodiack, the two Colures, the Horizon, the Meridian,

ridian, the two Tropicks, and the two Polars.

Thoſe Circles, are three manner of ways diſtinguiſhed among themſelves. Firſt, Some of them are called *Circuli Maximi*, the Greateſt Circles; others are called *Circuli Minores*, the leſſer Circles. The Greateſt are, the Equinoctial, the Zodiak, the two Colures, the Horizon, and the Meridian; becauſe there cannot be greater Circles in the Sphere, than they are.

The leſſer Circles are, the two Tropicks, and the two Polars. They are ſo called, becauſe there are found in the Sphere greater ones.

Secondly, The Circles of the Material Sphere, while the *Primum Mobile* is turning about, are either Parallel one to another, Right, or Oblique, that is, to ly croſly. The Parallel Circles, are the two Polars, the two Tropicks, and the Equinoctial, which ly middle between them, together with their Equinoctial, who live under the Poles. The Oblique Circles are, the Zodiack, and

t[illegible]

the Oblique Horizon. For this cutteth the Equinoctial, at Oblique Angles; the other by reason of its Situation doth the same to the rest of the Circles. The Circles called Right Circles, are the two Colures, the Meridian, and the Right Horizon, because they cut the Equinoctial at Right Angles.

Thirdly, The Circles of the Sphere, are either Moveable, or Immoveable. The Moveable Circles, are these which are turned about with the Sphere, being eight in number, to wit, the Equinoctial, the Zodiack, the Equinoctial Colure, the Solstice Colure, the Tropick of *Cancer*, the Tropick of *Capricorn*, the Polar Artick, and the Polar Antartick. The Circles Immoveable, are the Meridian, and the Horizon; so called, because while the Sphere is carried about, they stand stedfast, and unmoveable.

CHAP. II.

Of the Equinoctial.

THe Equinoctial, is one of the greateſt Circles, of the Sphere Moveable, and equally diſtant from the Poles of the World. It is called one of the greateſt, that it may be diſtinguiſhed from the leſſer, as well from thoſe, which are fixed in the Sphere, as from others, which we muſt imagine to be in it. It is called Movable, that it may be diſtinguiſhed from the Horizon of thoſe, who live under the Poles, which coinciding with the Equinoctial, muſt differ from it in this, that the one is Movable, the other Immovable. Laſtly, by reaſon of the third difference (equally diſtant from the Poles of the Sphere) it is diſtinguiſhed from the Oblique, and Right Circles of the Sphere.

It is called by divers Names. For ſometimes

ſometimes it is called the Equator, ſometimes the Equinoctial, and ſometimes the Middle, and greateſt of the Parallels.

The Uſes and Offices of the Equinoctial are theſe. 1. It meaſureth the firſt Motion. For this Circle, of all the Circles of the Sphere, under any Poſition whatſoever, moveth equally; and therefore, it ought to be alſo the Meaſure of Time, it being moſt fit for determining the quantity of the Artificial, and Natural Days. For this cauſe, it is, that the Degrees of the Equinoctial, are called by ſome, *Tempora*, Times. 2. It pointeth forth to us in the Ecliptick, the two Equinoctial Points; thoſe Points, in which the Equinoctial, and Ecliptick cut one another, in the beginning of *Aries* and *Libra*. For when the Sun cometh to theſe Points, the Day and the Night are of equal length over all the Earth, which falleth out on the 10 or 11 of *March*, and on the 13 or 14 of *September*. 3. That which is Anomolous, and Irregular in the Ob-

lique Motion of the Zodiack, is reduced to a ſure Rule, by the help of the Equinoctial. 4. It divideth the Sphere into two equal parts; the one called the North part, in which is the Pole, named *Polus Septentrionalis*, *Borens*, or *Articus*: the other called the South part, in which is the Pole, named *Polus Auſtralis*, *Meridionalis*, or *Antarticus*. 5. By this means, it divideth the Zodiack into ſix Signs, called Northern Signs, and into other ſix called Southern Signs. 6. From the Equinoctial are numbred the Declinations of all, and whatſoever Points in Heaven, as well South as North. The Declination of any Point, or Star, is an Arch of a Circle of Declination, meaſured between the Equinoctial, and the ſaid Point, or Center of the ſaid Star. Circles of Declinations, are of the Greateſt Circles in the Sphere Movable, paſſing thorow the Poles of the World, and any point given. 7. Upon the Equinoctial, we reckon the Right Aſcenſion of any, or whatſoever Point in Heaven.

Right

Right Aſcenſion, is nothing elſe, but an Arch of the Equinoctial, meaſured betweeen the firſt Point of *Aries*, and that Circle of Declination, which paſſes thorow the point given. 8. Upon the ſame Equinoctial, we meaſure the Oblique Aſcenſion, and Deſcenſion of any point in Heaven whatſoever. Oblique Aſcenſion, is an Arch of the Equinoctial, meaſured between the firſt Point of *Aries*, and that Point of the Equinoctial, which riſeth in the ſame Moment of Time, with the Point given. Oblique Deſcenſion, is an Arch of the Equinoctial meaſured between the Point foreſaid, and that Point of the Equinoctial, which ſets in the ſame Moment of Time, with the Point given. 9. Upon the Equinoctial, we count and reckon the Aſcenſional Difference, which is nothing elſe, but an Arch of the Equinoctial, by which Right Aſcenſion differs from Oblique. 10. Upon the Equinoctial, we meaſure the Riſing and Setting Amplitude. This Riſing and Setting Amplitude, is nothing elſe, but an Arch

of

of the Horizon, measured between the Rising, or Setting of the Equinoctial, and the Rising or Setting of any Star, or Point given. 11. Upon the Equinoctial, we number the Longitudes of Places, and upon the same, we reckon the Latitudes of Places. The Longitude of a place, is an Arch of the Equinoctial, measured between the first Meridian, and the Meridian of the Place. The Latitude of a Place, is an Arch of the Meridian measured between the Equinoctial, and Zenith of the Place. 12. The Equinoctial is most useful for making of Sun-Dials: for there must be as many Hours upon the Plain, as there are 15 Degrees in the Equinoctial, four and twenty times numbred.

CHAP. III.

Of the Zodiack.

THe Zodiack, is one of the Greatest Circles of the Sphere, Movable,

able, under which the Planets perpetually haunt.

The first and second Difference are added, as in the Definition of the Equinoctial. The third, which is in these words (under which the Planets perpetually haunt) do distinguish the Zodiack from all other Circles. For it may come to pass, that, this or that Planet, by his proper motion, may be under the Meridian, may be under some Horary Circle, may touch lightly the Horizon, but that is not always, nor do they always abide in the same Situation: but their stay is perpetual under the Zodiack. And because the Planets wander in the Heavens, *viâ obliquâ*, therefore this Circle is made oblique, and seing in this obliquity, they make digression, from this side, to that side, and from that to this, therefore Astronomers have granted to this Circle Latitude, whereby also it may be differenced from all other Circles, none of which ever claimed Latitude.

The Zodiack is divided, first in relation

tion to its Latitude, into North Latitude, and South Latitude. North Latitude, is that half part of the Zodiack, which from the Ecliptick (the middle Line of it) declines toward the North. South Latitude is oppoſite to this. Each one of them contains Eight Degrees, whereof the Equinoctial contains 360.

The Ecliptick, or middle Line of the Zodiack, is one of the Greateſt Circles of the Sphere, Movéable, under which, the Sun from Weſt to Eaſt moves perpetually. This Line, as likewiſe the Zodiack, is divided according to Longitude into twelve Parts, which are called in Greek *Dodekatemoria*. Every one of theſe twelve, are ſubdivided into 30 parts, ſo that the whole Zodiack contains 360 Degrees. Theſe twelve Diviſions are called *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpius*, *Sagittarius*, *Capricornus*, *Aquarius*, *Piſces*. But ſeing there are four Cardinal Points, two of the Equinoctial, and two Solſtice Points, it hath pleaſed Aſtronomers, to make the beginning of

their

their reckoning, from the Vernal Equinoctial Point; because the Sun being there, he not only begins the Spring, but openeth the Earth, and giveth life to all Vegetables, and things which grow; which cannot be done, either in any of the Solstices, or when he is in the Autumnal Equinoctial Point. Next, the distinction of the Signs is manifold. For some of them are called Northern Signs, and others are called Southern. The Northern, decline from the Equinoctial towards the North, which are *Aries*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*. The Southern decline from the Equinoctial towards the South, which are *Libra*, *Scorpius*, *Sagittarius*, *Capricornus*, *Aquarius*, *Pisces*.

Secondly, Some of them are called, Signs Ascending, others are called Signs Descending. The first sort, are these, wherein the Sun, and the rest of the Planets do ascend from the South towards our Zenith, which are *Capricornus*, *Aquarius*, *Pisces*, *Aries*, *Taurus*, *Gemini*. The Descending are these, wherein the Sun,

Sun, and the reſt of the Planets, do move from our Zenith towards the South, which are *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpius*, *Sagittarius*.

Thirdly, The Signs of the Zodiack, are either Vernal, Eſtival, Autumnal, or Hybernal. The Vernal, are *Aries*, *Taurus*, *Gemini*. The Eſtival, are *Cancer*, *Leo*, *Virgo*. Autumnal, are *Libra*, *Scorpius*, *Sagittarius*. And the Hibernal, are *Capricornus*, *Aquarius*, *Piſces*.

Fourthly, The Signs are either Cardinal, Middle, or Fixed, or Common, or Two-bodied. The Cardinal Signs, are *Aries*, *Cancer*, *Libra*, *Capricornus*: ſo called, becauſe their beginnings are the very Cardinal Points. The Middle or Fixed Signs, are *Taurus*, *Leo*, *Scorpius*, *Aquarius*. They are called Middle or Fixed, becauſe they keep the Middle place between the Cardinal and Common Signs. They are Fixed, becauſe when the Sun is in them, we have a perfect temperament of the Air, agreeing to the given Quadrant of the Heavens. As when the Sun is in *Taurus*, we

we have a perfect Spring; in *Leo*, a perfect Summer; in *Scorpius*, a perfect Harveſt; and in *Aquarius*, we have a perfect Winter. They are called Common, or Two-bodied, as *Gemini*, *Virgo*, *Sagittarius*, and *Piſces*; becauſe each one of them, hath two Bodies indeed. For *Gemini* are two Twins. *Virgo* hath an Ear of Corn in her Hand. *Sagittarius* is made up of a Man, and a Horſe. And laſtly, The *Fiſhes* are double. They are called Common, becauſe Aſtrologers find, that they participate of the Nature, both of the Fixed Signs, and the Cardinal which follow.

Fifthly, The Signs are divided into four Triplicities, which are called by Aſtrologers *Trigons*. The firſt is called the Fiery *Trigon*, which contains *Aries*, *Leo*, and *Sagittarius*. The ſecond is the Earthy, which contains, *Taurus*, *Virgo*, and *Capricorn*. The third is the Aerial, which contains, *Gemini*, *Libra*, and *Aquarius*. The fourth is the Watery, which contains, *Cancer*, *Scorpius*, and *Piſces*.

If it happen, that *Saturn*, and *Jupiter* be in Conjunction this year in *Leo*, their next Conjunction will happen 20 years after, or truly 19 years, 315 days, and 19 hours, after in *Sagittarius*. From *Sagittarius* to *Aries*, from *Aries* to *Leo*, and so in round till 198 years and 236 days passing, they make a Transit into a new Trigon; so that the Revolution of one Trigon, consumes almost 200 year.

The uses of the Zodiack and Ecliptick are these. 1. As the Equinoctial, is the Measure of the *Primum Mobile*, so is the Zodiack and Ecliptick, the Square and Rule of the second Movables. For as the Sun is always, in or under the Ecliptick; so are the rest of the Planets always, in or under the Zodiack. Therefore as in the Celestial Globe, the Zodiack hath the chief place, so in the Terrestrial Globe the Equinoctial. 2. Upon the Ecliptick we reckon the Longitude of Stars, and from the same Ecliptick, we count their Latitude. The Longitude of a Star, is an

Arch

rch of the Ecliptick, measured between
e true Equinoctial Point, or begin-
ng of *Aries*, and the Circle of Lati-
de passing thorow the Center of that
tar. Circles of Latitude, are great
lovable Circles, passing thorow the
oles of the Ecliptick, and the Center
f the Star given. They are of that
umber of Circles, which cannot be
laced Artificially in the Sphere. Ne-
erthelefs, of that same Number, is the
olurus Solfitiorum fixed in the Sphere.
he Latitude of a Star, is an Arch of a
ircle of Latitude, measured between
e Ecliptick, and the Center of the
tar. 3. According to the Degrees, and
arts of the Zodiack and Ecliptick, the
hole Heavens, and the whole Universe
divided into twelve Signs; nay eve-
y Point contain'd in the Sphere of the
ixed Stars, is said to be in this or that
gn; tho, *to be in a Sign*, is said many
ays. For first, To be in a Sign, is
othing else, but to be under any
velfth part of the Zodiack. In this
nse, the Sun is said to be in a Sign,
because

becauſe he is always under the Ecliptick. Then the Stars are ſaid to be in a Sign, which are indeed out of the Ecliptick, nevertheleſs are under the Zodiack. In this ſenſe, the Planets, which wander from the Ecliptick, are ſaid to be in the Sign of *Aries*, and *Taurus*, &c. Thirdly, Any thing is ſaid to be in a Sign, which is included, in any of the twelve parts, which ariſe from the diviſion of the whole Heavens, paſſing thorow the beginnings of the *Dodekatemoria*, or the Poles of the Ecliptick; they being ſix great Circles, which mutually cut one another, in the ſame Poles. In this ſenſe, any Star, as well fixed, as wandring, or new appearing, as a Comet, are ſaid to be in the Sign of *Aries*, *Taurus*, &c. 4. The obliquity of the Ecliptick, is the cauſe of the inequality of days: for ſeing it moves unequally, and not evenly, the Sun, which is the true Parent of Time, muſt of neceſſity make the days unequal. 5. The Year, the Month, and the four Seaſons of the Year, are determined by the

the Ecliptick. 6. When the Sun and Moon, are both of them in the Ecliptick, of neceſſity there muſt be Eclipſes; and for this cauſe, it is called the Ecliptick. 7. How much is the obliquity of the Ecliptick, ſo much is the diſtance, between the Poles of the World, and the Poles of the Ecliptick: ſo much alſo is the diſtance, between the Equinoctial, and either of the Tropicks.

CHAP. IV.

Of the Colures.

THe Colures are nothing elſe, but Circles of Declination, defined above, in the ſecond Chapter of the Equinoctial. They are called Colures from two Greek words, *Kolos*, or *Kolobos*, *Mancus*, maimed or defective, and *Oura*, *Cauda*, a Tail, becauſe in an oblique Sphere, they have ſome part unſeen, as if they were maimed, or wanting. But all the reſt of the Circles of

the Sphere, while it is going about, may be ſeen: but the Colures, have always ſome of their parts towards either of the two Poles, lying hid, and unſeen. There are only two of them, which uſe to be placed in the Sphere, one whereof is called the Solſtice Colure, the other the Equinoctial Colure: The Equinoctial Colure, is one of the greateſt Circles of the Sphere, Movable, paſſing thorow the Poles of the Sphere, and the Equinoctial Points, the firſt of *Aries*, and the firſt of *Libra*, which are called Cardinal. By the word movable, the Colures are differenced; Firſt, From the Meridian; Secondly, From the Right Horizon; And thirdly, From the Horary Circles, with all which, by one turning about of the Sphere, they are twice united. But in this they differ, that thoſe do not move, but theſe follow the motion of the *Primum Mobile*. The Solſtice Colure, is one of the greateſt Circles of the Sphere, movable, drawn thorow the Poles of the Sphere, and the two Solſtice Points, by which

which difference, they are diſtinguiſhed from other Colures.

The uſes of all the Colures in common are theſe. Firſt, We reckon upon them, the Declinations of all the Points of the Heavens whatſoever. 2. They terminate and bound the Right Aſcenſions. 3. They are like unto a Right Horizon, and a Meridian in any Sphere, whether Right, Oblique, or Parallel.

The Uſes of the Colures, which are ſet down in the Sphere, are theſe in common, 1. Without them, the Parallel Circles in the Material Sphere cannot ſtand, 2. By their mutual cutting one another, they ſhew the Poles of the Sphere. 3. They divide the Ecliptick into four Quadrants.

The peculiar Uſes of the Equinoctial Colure are theſe. 1. It demonſtrats to us the Equinoctial Points, by its mutual Section, with the Ecliptick; in which Points when the Sun is exiſting, there is an Univerſal Equinox over the whole Earth. 2. It it divides the Ecliptick

into two halfs, the one called the North part, the other the South part. 3. It diſtinguiſhes the Signs, in which when the Sun is exiſting, the Days are longer than the Nights, from thoſe Signs, in which when the Sun is exiſting, the Nights are longer than the Days.

The proper Uſes of the Solſtice Colure are, 1. It demonſtrats to us the two Solſtice Points, in which when the Sun is exiſting, he is either neareſt to our Zenith, or furtheſt removed from it. 2. Upon this Colure, we reckon the Suns greateſt Declination, or the greateſt Obliquity of the Ecliptick, which is found to be this day twenty three Degrees, and thirty Minuts. 3. It divides the Zodiack into two halfs; the one called Aſcending, the other Deſcending. 4. It diſtinguiſheth the Signs, in which when the Sun is exiſting, the Days become longer, and the Nights become ſhorter, from thoſe Signs, in which when the Sun is exiſting, the Nights become longer, and the Days become ſhorter. 5. In this Circle, are the two

Poles

Poles of the Ecliptick, as many Degrees, distant from the Poles of the World, as the greatest obliquity of the Ecliptick contains. 6. Upon this Colure, the Latitudes of the Zones are determined. For between the Tropicks, is contained the breadth of the Torrid Zone, between the Tropicks, and the nearest Polar Circles, are contained the two Temperate Zones, and the other two remaining Arches of this Circle, contain the breadth of the two Frigid, or Cold Zones.

CHAP. V.

Of the Horizon.

THE Horizon, is one of the greatest Circles of the Sphere, Immovable, and equally distant from the Vertical Point. It is called *Immovable*, that it may be differenced from the rest of the Movable Circles; but especially, First, From their Equinoctial, who live under

the Poles. Secondly, From their Ecliptick, whoſe Zenith is placed in the Polar Circles: for their Ecliptick every day is twice united with their Horizon, but without delay. Thirdly, From their Circles of Declination, or their Colures, who live under the Line: for there, the forementioned Circles, and the Horizon, are twice, by every Revolution of the Sphere, united: but the Circles of Declination follow the Motion of the *Primum Mobile*, but the Horizon ſtands Immovable. The Horizon is ſaid indeed to be Immovable, but not Unchangable, for there are as many Horizons, as there are Vertical Points; and while we change our Vertical Point, of neceſſity we change our Horizon alſo.

Two ways is the Horizon divided. Firſt, In relation to the Equinoctial, which is called a Right Horizon, an Oblique Horizon, and a Parallel Horizon. The Right Horizon, is ſo called, becauſe it cuts the Equinoctial at Right Angles. It is called Oblique, becauſe it

it cuts the Equinoctial at Oblique Angles. And it is called a Parallel Horizon, when it lies Parallel to the Plain of the Equinoctial, or rather when it is united, with the Equinoctial. And according to this Relation, it hath to the Equinoctial, the Sphere it ſelf, hath obtained the ſame Diviſion.

Secondly, The Horizon is either Rational, or Senſible. The Rational Horizon, is defined above, and is underſtood to divide the whole World, or Sphere of the World into two equal parts, the firſt whereof is called the uppermoſt Hemiſphere, the ſecond the nethermoſt Hemiſphere. It is called Rational, becauſe tho we cannot ſee the whole World, or the exact half of it, yet Reaſon tell us, by the Riſing and Setting of the Sun, Moon, and Stars, that the inferior part of the World, is equal to the ſuperior part. The Senſible Horizon, is nothing elſe, but ſo much of the Earth, as a man, by turning his eye once, doth behold round about him.

The

The Uſes of the Horizon are theſe. Firſt, it divides that part of the Heavens, which is ſeen, from the other which is not ſeen, the Superior part from the Inferior part. 2. Thorow the Poles of the Horizon the Meridian ought to paſs: therefore the Deſcription of the Meridians depend from the Horizon. 3. By the Situation of the Horizon, we know whether it be a Right Sphere, Oblique Sphere, or a Parallel Sphere. 4. In the Horizon, the Riſing or Setting of the Stars are obſerved. 5. The Horizon ſheweth, what Degree of the Ecliptick, what part alſo of the Equinoctial, or what Degree, with any given point of the Heaven riſeth or ſetteth. 6. It boundeth and terminats the Aſcenſional Difference. 7. Upon the Horizon is numbred, the Riſing or Setting Amplitude, of any point in the Heaven. 8. It demonſtrats, and ſheweth the Cauſe and Reaſon of the equality of Days and Nights in a Right Sphere, and of the unequality of the ſame in an Oblique Sphere. For the

Horizon

Horizon in a Right Sphere cutteth all he Circles of the Natural Day equally, but unequally in an Oblique Sphere. 9. From the Horizon we number the Morning-Twilight: for when the Sun s distant, in some Vertical Circle 18 or 19 Degreees from the Horizon, so that from that Moment, he approach nearer nd nearer unto it, then begins the Morning-Twilight. But the Evening-Twilight ends, when the Sun after his Setting comes to that 18 or 19 Degree foresaid; for then doth the Light turn nto Darkness. 10. From the Horizon, we number the Elevation of the Pole, nd Equinoctial. 11. From the Horizon are numbred various and divers kinds of Hours, as the *Italick*, and *Jewish* Nocturnal Hours from the West part of he Horizon: but the *Babylonish* Hours, nd the *Jewish* unequal Diurnal Hours, rom the East part.

CHAP.

CHAP. VI.

Of the Meridian.

THe Meridian is one of the greateſt Circles in the Sphere, paſſing thorow the Poles of the World, and the Poles of the Horizon. By the words, *thorow the Poles of the Horizon*, it is diſtinguiſhed from the Horary Circles, of which none but it ſelf, paſſes thorow the Poles of the Horizon. It has acquired divers and ſundry Names, by reaſon of its manifold uſes, by Aſtrologers, which are not fit to repeat now. What was ſaid above concerning the Colures, and Circles of Declination, to wit, that they are in number equal to the Vertical Points, the ſame may be ſaid of the Meridian, for as many of them may be imagined, as there are Vertical Points, which are infinite, providing a man travel from Eaſt to Weſt: for if a man go from North to South, or

or from South to North, he travels round about the World, without variation of his Meridian. The Braſen Meridian in the Celeſtial, or Terreſtrial Globe, ſupplyes the office of them all, which are innumerable. But in Geographical Tables, and Mapps, Geographers uſe to extend one Meridian, thorow two, and two oppoſite Degrees of the Equinoctial, for finding out, the more eaſily the Latitudes of Places. Of all theſe Meridians there is a common beginning ſetled in the *Fortunate*, or *Canary Iſlands*, becauſe the Antient Geographers deemed thoſe Iſlands to be the Weſtmoſt part of the World, and therefore they fixed their firſt March-ſtone there, whence they begin to reckon. But the later Geographers, have removed this March-ſtone 10 Degrees more Weſterly, and have made the common beginning of the Meridian to paſs thorow one of the Iſlands called *Oſores*, whence they begin to reckon from Weſt to Eaſt, imitating the order of the 12 Signs.

The uſes of the Meridian are theſe,

1. It

1. It diſtinguiſheth the Eaſtern part, of the World, from the Weſtern part, the Anterior part, from the Poſterior part. 2. It lets us know the South part of the World, and the North part. For when the Sun is in the Meridian, then is Mid-day, and when the Sun is in the Northern part, of the Meridian, then is Mid-night. 3. It divides the Nocturnal and Diurnal Time into two halfs: that is, when the Sun is come to the Meridian in our Hemiſphere, as much of the day is paſt, as what is to come: and when the Sun is come to the Northern part of the Meridian, as much of the Night is paſt, as what is to come. 4. The Meridian ſupplies in every Oblique Sphere the place of the Right Horizon: therefore, as the Stars do aſcend above the Right Horizon, ſo they paſs over the Meridian, and thoſe Tranſitions are called the Right Aſcenſions of the Middle Heaven. 5. From the Meridian, Aſtronomers begin their Time. 6. In the Meridian, we find out the Zenith; therefore when the Stars

Stars come to it, they are either highest above the Horizon, and are ſaid by Aſtrologers to culminate, or they are in the loweſt, and oppoſite part of it, which is the Nadir. 17. In the Meridian, we find out the diſtances between the Tropicks, and the whole Obliquity of the Ecliptick. 18. Upon the Meridian, we number the Latitude of Places upon the Earth, and likewiſe the Elevation of the Pole, and Equinoctial. The Elevation of the Pole, is defined, an Arch of the Meridian, meaſured between the Horizon, and the apparent Pole of the World, which may be found out, after the following manner. Obſerve the greateſt and leaſt Altitude of any of the Stars, which do not ſet. Subtract the leaſt Altitude from the greateſt, and divide the difference. This difference being ſubtracted from the greateſt Elevation, or added to the leaſt, gives the true height of the Pole. *December* 17. 1669, I obſerved with a large Quadrant, half 9 a Clock at night, the foremoſt Guard-ſtar, when it was

in

in the Meridian, and loweſt, to have 41 Degrees, 22 Minuts of Altitude. And on *January* 7. 1670, at 7 a Clock in the Morning, I found it, when it was in the Meridian, and heigheſt, to have 70 Degrees, 27 Minuts. I ſubtract 41 Degrees, 22 Minuts, from 70 Degrees, 27 Minuts, and the difference is 29 Degrees, 5 Minuts. Divide this, and you have 14 Degrees, 32 Minuts, and 30 Seconds. This being added to 41 Degrees, 22 Minuts, gives you 55 Degrees, 54 Minuts, 30 Seconds. Or ſubtract 14 Degrees, 32 Minuts, and 30 Seconds, from 70 Degrees, 27 Minuts, and there remains 55 Degrees, 54 Minuts, and 30 Seconds, for our height of the Pole at *Edinburgh*. 9. The Meridians do terminate, and bound the Longitudes of Places, as well in the Terreſtrial Globe, as in the Mapps, and Cards projected in *Plano*. 10. The Meridians do terminate, and bound the Breadths and Latitudes of the Zones, and alſo of the Climats. 11. We find out in the Meridian, the *Antipodes*, the *Anteci*, and *Perieci*.

CHAP.

CHAP. VII.

Of the Tropicks.

THe Tropicks are leſſer Movable Circles of the Sphere, deſcribed from the Solſticial Points, by the motion of the *Primum Mobile*. They are called Leſſer, becauſe there are in the Sphere Greater Circles, than they are. They are called Movable, that they may be diſtinguiſhed chiefly, from the Parallels of their Horizon (called Almicantars), who live under the Poles ; and from the antient Polars of thoſe, who live under the Polars, with whom the Tropicks are equal to thoſe Circles, which comprehend the Stars, which never come above the Horizon, nor ever go under it.

They are two in number, to wit, the Tropick of *Cancer*, and the Tropick of *Capricorn*. The Tropick of *Cancer*, is a leſſer movable Circle, deſcribed from the

the Summer-Solſtitial-Point of the Eclip
tick, by the motion of the *Primum Mo*
bile. The Tropick of *Capricorn*, is
leſſer movable Circle, deſcribed fron
the Winter-Solſtitial-Point of the Eclip
tick, by the motion of the *Primum Mo*
bile.

The uſes of the Tropicks are theſe
1. They demonſtrate to us, in the E
cliptick, the two Tropical or Solſtic
Points, to wit, the beginning of *Can*
cer, and the beginning of *Capricorn*
2. They terminate and bound, the Sun
greateſt Declination, and conſequentl
the greateſt Obliquity of the Ecliptick
3. When the Sun comes to either of th
two Tropicks, he is either neareſt t
our Vertical-Point, or furtheſt removed
from it. 4. In an Oblique Sphere, they
ly Parallel to the longeſt, and ſhorteſ
Day. 5. Between the Tropicks, i
comprehended the Torrid Zone, as wel
in the Heavens, as in the Earth: and by
the ſame Tropicks, the Torrid Zone
is divided from the Temperate Zones.

CHAP

CHAP. VIII.

Of the Polars.

THe Polars are leſſer Circles of the Sphere, movable, deſcribed from the Poles of the Ecliptick, by the motion of the *Primum Mobile*. For this cauſe, they are called the Polar Circles. They are two in number, the Polar Artick, and the Polar Antartick. The Polar Artick is a leſſer Circle of the Sphere, movable, deſcribed from the North Pole of the Ecliptick, by the Motion of the *Primum Mobile*. The Polar Antartick, is a leſſer Circle of the Sphere, movable, deſcribed from the South Pole of the Ecliptick, by the motion of the *Primum Mobile*.

They let us ſee firſt, the Poles of the Zodiack, and they meaſure their diſtance from the Poles of the World. 2. They bound the Temperat Zones, and ſeparats them from the Cold Zones, which

are bounded and incloſed by their circumferences. It is to be obſerved, that the antient Aſtronomers, *Proclus*, *Cleomedes*, and the reſt, had not the ſame deſcription of the Polars, which we have. For the Antients, did not deſcribe them, as paſſing thorow the Poles of the Ecliptick, but thorow the *common Sections* of the Meridian, and Horizon, equidiſtant to the Equinoctial: and therefore, ſo much was their diſtance from the Poles of the World, as the height of the Pole was above the Horizon. And by this means, where there is no Elevation of the Pole, as in a Right Sphere, there are no Polars. But from thence, they are more, and more gradually augmented, and enlarged, according to the increment of the Poles Elevation.

The uſes of the Polars, according to the Antients, are theſe, 1. They comprehend the Arch of the Elevation of the Pole. 2. Of all the Parallels of the Equinoctial, which are always ſeen above the Horizon, they are the greateſt, and

nd of all the Parallels of the Equino-
tial, which ly hid under the Horizon,
hey are the greateſt alſo. But contra-
iwiſe, of all the Parallels of the Equi-
noctial, which ariſe and ſet in twenty
four Hours, they are the leaſt. There-
fore (3.) the foreſaid Polars, compre-
end within their Compaſs, and Circle,
he whole Stars and Points of Heaven,
which are always in ſight, and do not
et. Hence, there ariſeth a threefold
iſtinction of the Stars. 1. There are
ome, which have a perpetual Day, and
never ſet; or fall under the Horizon, to
wit, thoſe which are comprehended
within the Circle of the Polar Artick.
. There are others, which have a per-
petual Night, which never riſe, or come
p above the Horizon, to wit all thoſe,
which are included within the Circle of
he Polar Antartick. There are (3.) o-
hers which both riſe and ſet in four
nd twenty Hours, to wit thoſe, which
ither on this ſide, or that ſide of the
Equinoctial, tend towards and come
neareſt to the foreſaid Polars.

CHAP. IX.

Concerning other Circles of the Sphere, both greater and leſſer, which cannot be conveniently drawn upon it.

BEſide the Circles of the Sphere hi therto explained, there are yet in numerable more, both of the greateſt and leſſer ſort, which Aſtronomers have excogitated for attaining a more perfect knowledge of the *Heavenly Motions*. 1. There are of the greateſt ſort Verti cals, which paſs thorow every point o the Horizon, cutting one another there which by the *Arabians* are called Azi muths. 2. There are the Horary Cir cles, which divide the Heavens, int four and twenty parts, which are o three ſorts. For either they have the beginning in the Meridian, and pa thorow the Poles of the World, or the have their beginning in the Eaſt, o Weſt-part of the Horizon, by whic

mea

means they touch lightly, the two Circles lying parallel to the Equinoctial, of which one is the greateſt of all, which are always ſeen above the Horizon, the other the greateſt of all, which are not ſeen above the Horizon: or laſtly, they have their beginning in the Horizon, but neither go thorow the Poles, of the World, nor go near to the foreſaid Parallels, but divide all the Segments of the Parallels, which are above or below the Horizon, into twelve equal parts. 3. There are Circles of Declination, which paſs thorow the Poles of the World, and every point of the Equinoctial. There are 4. Circles of Latitude, which paſs thorow the Poles of the Ecliptick, and every one of his Degrees.

The leſſer Circles are infinite alſo; for there is no great Circle, which hath not his own Parallels. As firſt the Horizon, which hath Circles of Altitude, called by the *Arabians* Almicanthars. The Equinoctial, hath its own Parallels, to wit, deſcribed by the *Primum Mobile*

bile, from all, and whatſoever Points are in the Heavens. So hath the Zodiack his Parallels, deſcribed about the Poles of the Ecliptick, which Parallels every Star, or point of the Heavens, according to the proper motion of the eight Sphere, do deſcribe, and many more are there invented by Aſtronomers for Aſtronomical uſes.

CHAP. X.

Of the Zones.

TO the Doctrine of the Sphere, is commonly annexed the Geographical Tractat of the Zones. The Zones therefore are nothing elſe, but as much bounds, of the Heaven, or of the Earth, as is comprehended between both the Tropicks, or between either of the two Tropicks, and the next Polar, or between either of the two Polars, and the neighbouring Pole. Therefore the Zones,

Zones, are either Celeſtial, or Terreſtrial. The Celeſtial Zones, are bounded by themſelves, and their own Circles in the Heavens. The Terreſtrial Zones, ly directly under the ſame places of the Heavens. They are five in number, one Torrid, two Temperate, and two Frigid. The Torrid Zone, is that ſpace of the Heavens, or the Earth, comprehended between the two Tropicks. This is divided into two parts, of which one is called the Northern, the other the Southern part. It is called Torrid, becauſe here, the Rays of the Sun are more perpendicular, and ſo hotter, that the Inhabitants are in a manner ſcorched, and burnt up with Heat. The Temperate Zones, are that ſpace of the Heavens, or of the Earth, comprehended between either of the two Tropicks, and the neighbouring Polars: and that which is included, between the Tropick of *Cancer*, and the Polar Artick, is called the Temperate Northern Zone, wherein are contained, all *Europe* almoſt, and a great part of *Aſia*, and alſo a part

a part of *America*. But that which is included between the Tropick of *Capricorn*, and the Antartick Polar, is called the Southern Temperate Zone. This contains more Sea, and leſs Land. They are called Temperate, becauſe the Rays of the Sun, being more oblique, there is not ſuch a reflection of Heat, but offer a moſt commodious Dwelling to the Inhabitants. The Frigid Zones, are that ſpace of the Heavens, and of the Earth, comprehended between either of the Polars, and the neighbouring Pole of the World. And that bounds, which is included between the Polar Artick, and the North Pole, is called the Northern Frigid Zone: and that bounds which is included, between the Polar Antartick, and the South Pole, is called, the Southern Frigid Zone. They are called Frigid, becauſe the Rays of the Sun are moſt Oblique, and are abſent almoſt half a Year; ſo that all things become rigid and ſtiff, with Froſt, Yce, and Snow. In this Zone, lyes *Iſland* and *Greenland*, but in the Southern

Southern cold Zone, the parts are unknown to us.

The Inhabitants of the five Zones, have obtained divers names. For thoſe, who inhabite the Torrid Zone, are called *Amphiſcii*, as having a ſhadow on both ſides. I ſay on both ſides, in reſpect of the Vertical Point. For the Sun with them, is ſometimes on this ſide, and ſometimes on that ſide of their Vertical Point: ſometimes the ſhadow of their Dials is projected from South to North, and ſometimes from North to South, when he is in the Meridian. The Inhabitants of the Temperate Zones, are called *Heteroſcii*, as having but one ſhadow. For at 12 a Clock in the Day, the ſhadow is either caſten towards the North, as with us, or towards the South, as with thoſe, who dwell in the Southern Temperate Zone. But thoſe, who live in the Frigid Zones, are called *Periſcii*, as having a ſhadow, which goes round about them; becauſe they have the Sun for ſeveral Months of the Year, above their Horizon, and

the

the Heavens there, like a Millſtone, is whirled about, ſo that the Sun and Stars deſcribe Parallels to the Horizon, and therefore in four and twenty Hours, he runs about without riſing and ſetting, and projects his ſhadow into an Orb, or Circle.

There are likewiſe, the *Antipodes*, *Antœci*, and *Perieci*. *Antipodes*, are thoſe, who have the ſame Meridian, but dwell in points of it, *diametraliter* oppoſite, and are under oppoſite Parallels, (to wit in an oblique Sphere,) of which the one is Southern, the other Northern. Theſe following Phenomena, are proper to them. 1. Though they have the ſame Rational Horizon, yet beholding the oppoſite Faces, all things fall out to them contrariwiſe. For when we have Day and Mid-day, our *Antipodes* have Night and Mid-night. When we have Summer, they have Winter. When the Sun riſes to us, he ſets to them. We have North Latitude, they have South Latitude.

The *Antœci* are thoſe, who dwell under

der oppoſite Parallels, equally diſtant from the Equator, towards both the Poles, under the ſame Meridian, but not in Points *diametraliter* oppoſed, but in a Semi circle of the Meridian intercepted between the Poles. They have theſe Phenomena proper to them. Firſt, They agree in the ſame Longitude, and Latitude; for how much is the South Pole elevated to thoſe, ſo much is the North Pole elevated to theſe. 2. In the ſame Moment of Time, both of them have the Sun in their Meridian. But in this they differ; while the Sun is coming to the Tropick of *Cancer*, thoſe have Summer and longer Days, but theſe have Winter, and ſhorter Days. Again, when the Sun is returning, thoſe have Harveſt, the Days Decreaſing, but theſe have the Spring, the Days Increaſing. Hence it is, that the Sun doth not riſe, and ſet to both, at the ſame time.

The *Periect* are thoſe, who dwell under the ſame Parallel and Meridian, but in Points of the ſame Parallel *diametraliter*

Inter oppoſite; ſo that both of them behold the ſame Pole, with equal height above the Horizon. Firſt, They dwell in the ſame Zone. Secondly, They have the ſame Elevation of the ſame Pole. They have the ſame Winter, the ſame Summer, the ſame longeſt Day, and the ſame increment, and decrement of the Natural Days. But here they differ; thoſe having the Sun riſing, theſe have it ſetting; thoſe having the Sun in the Meridian, theſe have it at our Mid-night: and contrariwiſe, when to thoſe the Sun is ſetting, to theſe he is riſing, when to thoſe it is Mid-night, to theſe it is the Meridian.

CHAP. XI.

Of the Riſing and Setting of the Stars according to the Poets.

HItherto we have treated of the Hypotheſes, to wit, the Circles of the Sphere, which ſo much conduce for

for explaining the Phenomena of the *Primum Mobile*. It now remaineth, that we ſpeak and treat of the thing it ſelf, to wit, the Phenomena themſelves. And in the entry, we ought to have ſpoken of the riſing and ſetting of the Stars, called *Ortus & occaſus ſtellarum Aſtronomicus*; but the knowledge of thoſe things, cannot be taught here compendiouſly, nor without the Science of *Spherical Trigonometry*; therefore paſſing this, we come to explain the riſing and ſetting of the Stars, called *Ortus & occaſus Poeticus*, which is the ſecond Phenomenon of the *Primum Mobile*.

This riſing and ſetting of the Stars according to the Poets, is nothing elſe, but the riſing of a Star above the Horizon, and the ſetting of a Star under it, in relation to the various Poſition of it, with the Sun. It is called Poetical, not becauſe it doth not belong to Aſtronomers; for it is a part of their Science to determine thoſe Riſings and Settings, but becauſe the Poets in deſcribing certain

gain Seasons of the Year, use this method, as will be seen afterward.

Of this Poetical Rising and Setting, there are three forms. First, That which is called the Rising and Setting of a Star *Cosmice*. Secondly, That which is called the Rising and Setting of a Star, *Acronyce*. Thirdly, That which is called the Rising and Setting of a Star *Heliace*. Each one of those hath a double signification; one general, the other special. The Rising of a Star *Cosmice* generally taken, is the Rising of a Star above the Horizon, falling out from the Rising of the Sun to his Setting. The Setting of a Star *Cosmice*, generally taken, is the Setting of a Star, falling out from his Rising to his Setting. The Rising of a Star *Acronyce*, generally taken, is the Rising of a Star above the Horizon, falling out the whole time, the Sun is under the Horizon. The Setting of a Star *Acronyce* generally taken, is the Setting of a Star under the Horizon, falling out all the time the Sun is under the Horizon. The Rising of a Star *Heliace* gene-

rally

rally taken, is the appearing of a Star after the Sun is Risen. The Setting of a Star *Heliace* generally taken, is the disappearing of a Star, after the Sun is set. But their special signification denotes, and determines, a certain, and definite time. Therefore, the Rising of a Star *Cosmice*, is the ascending of a Star above the Horizon, in the same moment, wherein the Sun Rises. The Setting of a Star *Cosmice*, is when a Star goes down, while the Sun is Rising. The Rising of a Star *Acronyce*, is when a Star comes above the Horizon, the Sun going down under the Horizon that same moment. The Setting of a Star *Acronyce*, is when a Star Sets with the Sun, that same moment. The Rising of a Star *Heliace*, is when a Star, which could not be seen, by reason of its nearness to the Sun, is now seen in the night time. The Setting of a Star *Heliace*, is when a Star, by reason of the Suns great distance from it, might have been seen in the night time, but the Sun coming nearer to it, it disappears out of our sight.

We

We have an Example of the Rising of a Star *Cosmice*, in the first Book of the *Georgicks*.

Vere fabis satio: tunc te quoque Medica pubres
Accipiunt sulci, & Milio venit annua cura
Candidus auratis aperit, cum Cornibus annus
Taurus, *& adverso cedens Canis occidit Astro.*

When *Taurus* with his gilded Horns,
Begins the Year, then Sowe your *Corn*:
Sowe *Millet-seed*, an yearly toil,
Sowe *Clover-grass*, in putrid soil,
Sowe yearly *Pulse*, and what you please
Sowe in the Spring, both *Beans* and *Pease*.

Virgil doth express here the Spring time, when the *Millet-seed* is to be sown, which is in the beginning of *April*: And seing the Sun at that time, is about the

end

end of *Aries*, it muſt be underſtood of the Riſing of *Taurus*, which at that time riſeth with the Sun *Coſmice*. At this time the *Romans* uſed to ſowe their *Beans*, their *Claver-graſs*, and their *Millet*, which every year muſt be renewed; whereas the *Claver-graſs* is to be ſown but once in ten years.

We have likewiſe an Example of the Setting of a Star *Coſmice*, from that ſame place in *Virgil*.

Ante tibi Eoæ Atlantides abſcondantur
Gnoſiaque ardentis decedat ſtella Coronæ
Debita quam ſulcis committas ſemina.

When *Pleiades*, the Maidens ſeven,
Are ſet into the Weſtern-Heaven,
When *Ariadnes* Crown full bright
Before the Sun comes in our ſight,
Then ſowe your Ground with *Wheat* and *Rye*
'Tis of *October* eighteen day.

Before you ſowe your Ground (ſays he)

he) let the *Pleiades*, or *Seven-ſtars* be ſet, which about *October* 18, go down in the Weſt, in the ſame Moment of Time, while the Sun is Riſing in the Eaſt, which is called *Occaſus Coſmicus*.

We have an Example of the Riſing of a Star *Acronyce*, from *Ovid*, in his firſt Book *de Ponto*.

Quatuor autumnos Pleias *oria facit.*

Four Harveſts ſurely there have been,
For *Pleias* four times have been ſeen.

Ovid is here ſpeaking of the Harveſt time, when the Sun is in *Scorpio*, therefore when the Sun is Setting, *Taurus* or *the Bull*, and the *Pleiades* are Riſing *Acronyce*.

We

We have alſo an Example of the Setting of a Star *Acronyc* from the ſame *Ovid*, in his ſecond Book *of his Faſts.*

Illa nocte aliquis tollens ad ſidera vultus
Dicet ubi eſt hodie, quæ Lyra fulſit heri.

Laſt Night when I ſurveyed the Sky,
I ſaw the *Harp*, 'tis gone away
This Night.

This time, is the ſecond day of *February*, at which time the Conſtellation called the *Harp*, ſets *Acronyce*, with the Sun.

We have likewiſe an Example of the Riſing of a Star *Heliace*, from the firſt Book *of the Georgicks.*

Gnoſiaque ardentis decedat ſtella Coronæ.

When *Ariadnes* Crown full bright

Before the Sun comes in our sight.

'Tis evident that *Virgil* speaks here of the Rising of this Constellation *Heliace*, called *Aridnes* Crown, when the Sun is in the beginning of *Scorpio*. For seing this Constellation rises at *Rome*, where *Virgil* lived, with the 27 Degree of *Virgo*, it is needful to conceive this Crown to be seen in the Morning, the Sun being yet under the Horizon.

Note, That there is a Figure called *Hypallage* in the word *Decedat*: for the Crown doth not recede from the Sun, but the Sun from it.

And lastly, We have an Example of the Setting of a Star *Heliace*, from the same place of *Virgil*.

Taurus, & adverso cedens Canis occidit Astro.

And when the *Dog* shall disappear,
By *Phebus* Beams him coming near.

The

The Poet is here ſpeaking of the Suns ingreſs into *Taurus*, which fell out in *Virgils* time on the 15 of *April*. But ſeing the Dog-ſtar ſets at *Rome* with the 22 Degree of *Taurus*, therefore, the Sun ſetting in the Evening, the Dog-ſtar ſetteth *Heliace*, or diſappears out of our ſight, by reaſon of the Suns Rays, which now are nearer him.

Obſerve, That what Stars do ariſe *Coſmice*, which is alſo called *Ortus Matutinus*, they ſet *Acronyce*, which is called *Occaſus Veſpertinus*; and what Stars do ariſe *Acronyce*, which is called *Ortus Veſpertinus*, they ſet *Coſmice*, which is called *Occaſus Matutinus*, according to the following Rhyme.

Coſmice *deſcendit ſignum, quod* Chronice *ſurgit*,
Chronice *deſcendit ſignum, quod* Coſmice *ſurgit*.

Aliter.

Mane vehit ſupra terram tibi Coſmicus *ortus*

Sidera, ſed Phœbi *lumine tecta latent.*
Mane dat Heliacus *quædam ſubvecta videre*
Aſtra, ſed Achronycus *nocte videnda trahit.*

Note ſecondly, That the word *Coſmicus*, comes from *Kosmos*, the World. That the word *Chronicus*, comes from the *Greek* word *Chronos*, Time. But *Acronycus* comes from *Acra & Nux*, which is the firſt part of the Night, or the Evening-Twilight. That *Heliacus* comes from *Helios*, the Sun. Laſtly, That *Chronice*, and *Acronyce* have the ſame ſignification.

CHAP. XII.

Concerning the Natural, and Artificial Days.

NOw follows another Phenomenon of the *Primum Mobile*, to wit, the Doctrine of Days Natural and Artificial.

cial. Days are twofold, Aſtronomical, and Civil. Aſtronomical Days, are ſuch as are meaſured, by the Revolutions of the Equinoctial, and determined by a certain quantity. Days Civil, are ſuch as every Nation, according to their own Cuſtom make uſe of. The Aſtronomical Day, is either Natural, or Artificial. The Natural Aſtronomical Day, is a ſpace of time, wherein the Sun, by the Motion of the *Primum Mobile*, being carried about, from whatſoever immovable point of the Heavens, returns to that ſame point again. Theſe Aſtronomical Days have their beginning in the Meridian, as was inſinuate before. The Artificial Aſtronomical Day, is a Space of Time, wherein the Center of the Sun remains above the Horizon. And the Artificial Night, is as much Time, as the Center of the Sun remains under the Horizon.

The Doctrine of the Artificial Days and Nights, is contained in the following Theorems. 1. The Artificial Days and Nights, with the *Amphiſcii*, *Heteroſcii*,

roſcii, and partly with the *Periſcii*, are parts of the Natural Day: but with the *Periſcii*, in thoſe parts of the Earth, wherein the Sun, by the going about of the *Primum Mobile*, perfects ſome Circumgyrations, either above the Horizon, without ſetting, or under the Horizon, without riſing, one Artificial Day, or one Artificial Night, doth excreſce into many Natural Days; ſo that indeed under the Poles, the Artificial Day contains half a Year, and the Artificial Night as much; and ſo to ſpeak properly, the whole Year conſiſts but of one Day, men looking to the Analogy of the Natural Day. 2. Under a Right Sphere, the Artificial Day, is equal to the Night: for the Horizon, in this Poſition of the Sphere, cuts the *Circuli Dierum*, the Day-Circles, into two equal parts. The Day-Circles, are called thoſe Parallels of the Equator which the Sun doth dayly deſcribe, by the Motion of the *Primum Mobile*. 3. In an Oblique Sphere, there are only twice a Year, two Equinoxes, when the Sun

is

is in the beginning of *Aries* and *Libra*. The Reaſon of this appears, from the mutual Section of the Horizon, with the *Circuli Dierum*, or Day-Circles, which is indeed unequal, except when the Sun is in the Equinoctial. 4. In an Oblique Sphere, which hath the viciſſitude of the Artificial, and Natural Day, by one Revolution of the Equator, the Sun being in the Tropick of *Cancer* (we are now ſpeaking of this uppermoſt part of the Sphere) we have the longeſt Day in all the Year, and the ſhorteſt Night: but the Sun being in the Winter Solſtice, the Day is ſhorteſt, and the Night longeſt. 5. In the ſame Poſition of the Sphere, thorow the whole half of the Ecliptick deſcending, the Sun maketh the following Days ſhorter, than the Days going before, but the Nights longer. But in the half of the Ecliptick aſcending, the Sun maketh the Days following longer, than the Days going before, but the Nights ſhorter. 6. When the Sun is exiſting in places of the Ecliptick, equally diſtant,

ſtant, from the ſame Solſtitial Point, Days are equal to Days, and Nights to Nights. 7. When the Sun is exiſting in places of the Ecliptick equally diſtant, from the ſame Equinoctial Point, the Day of one Place, is equal to the Night of another. 8. In an Oblique Poſition of the Sphere, the greater the Elevation of the Pole is, the greater are the increments of the longeſt Day, and ſhorteſt Night, until coming under the Polars, the longeſt Day contains twenty and four Hours. 9. In an Oblique Sphere, of ſuch as dwell between the Polar, and next Pole, the longeſt Day excreſceth into many Natural Days, as alſo the longeſt Night. But there are certain intermediat Horary Circles, a part of which is above the Horizon, and a part under, in which, when the Sun is exiſting, the Artificial Days, as alſo the Nights, are parts of the Natural Day. 10. In a Parallel Sphere, ſuch as they have, who live under the Poles, the whole Year, is divided into one Artificial Day, and one Artificial Night.

The

The length of every Artificial Day, is known by the Diurnal and Nocturnal Arch. First, find the Oblique Aſcenſion or Point of the Equinoctial, which riſeth with the Sun, and Oblique Deſcenſion, or Point of the Equinoctial, which ſetteth with the Sun. Subtract the leſſer from the greater, and half the difference, is the Aſcenſional difference, which added to ſix Hours in the Summer half Year, but ſubtracted therefrom in the Winter half Year, gives half the Diurnal Arch, whoſe double is the whole Diurnal Arch, and the Complement of the Diurnal Arch to 24 Hours, is the Nocturnal Arch. For Example, The tenth day of *April* 1687. the Oblique Aſcenſion of the Sun (being in the firſt Degree of *Taurus*) is 10 deg. 21. m. the Oblique Deſcenſion is 45 deg. 27 m. whoſe difference is 35 deg. 6. m. whoſe half is 17 deg. 33 m. the Aſcenſional difference, which being added to 90 deg. or 6 Hours, is 107 deg. 33 m. which make 7 hours, 10 m. *fere*, for the time of the Suns ſetting, which is always

always half the Diurnal Arch. Therefore the Diurnal Arch is 14 hours, 20 m. Which taken from 24 hours, there remains 9 hours, 40 m. for the Nocturnal Arch required. *Note*, That the Aſcenſional difference added to the Oblique Aſcenſion in the Summer half Year, but ſubtracted from it, in the Winter half Year, gives the right Aſcenſion of the Sun, or any of the Stars.

What is ſaid of the Day in reſpect of the Sun, may be moſt commodiouſly applyed to the Stars. For the Day of a Star, is rightly called the ſpace of Time, wherein it is above the Horizon: and the Night of a Star, the ſpace of Time, wherein it is below the Horizon. Concerning the days of the fixed Stars, let the following Theoremes be obſerved. 1. In a Right Sphere, the Stars have a perpetual Equinox. 2. But in an Oblique Sphere, the fixed Stars, whoſe North Declination, is greater than the Complement of the Altitude of the Pole, are ſaid to have an Eternal Day: but thoſe Stars, whoſe South Declination,

olination, exceeds the Complement of the Altitude of the Pole, are said to have an Eternal Night. The intermediate Stars, have the course of rising and setting. 3. In a Parallel Sphere, the fixed Stars are said to have Eternal Days, and Eternal Nights.

Days Civil, are called the space of Time, of one Revolution of the Equinoctial, which according to every Nation, or Country, is divers ways begun, and made use of. For as there are various and divers Nations in the World, so each one hath a different way of beginning their Hours. For the *Jews*, by Divine Institution, began their Day, from the setting of the Sun, which custom the *Italians* do observe. The *Babylonians* began their Day from Sun rising, whose practice, the *Norinbergers*, the People called the *Umbri*, and the *Egyptians* do imitate. The *Arabians* as the Astronomers, begin their Day from the Meridian. The *Romans* from Midnight. The *Germans*, the *Brunchers*, and *Spaniards* begin their Day from the Meridian,

Meridian, and Mid-night. For their Clocks, and Watches are ſo contrived, that they return from one a Clock in the Night-time, to twelve a Clock in the Day-time, and from one a Clock in the Day-time, to twelve a Clock at Night-time. Their Days are divided, as the Aſtronomical Days, into one Artificial Day, and likewiſe into Forenoon, and Afternoon.

And becauſe Hours are parts of the Days, therefore we muſt ſpeak a little of them. The Hour is the twentieth and fourth part of the Natural Day, or the ſpace of Time, wherein the twentieth and fourth part of the Equinoctial, or 15 Degrees thereof, riſeth above the Horizon. But this Definition is not ſufficient, becauſe it doth not agree to all Hours: for every twelfth part of every Day, and every Night whatſoever, was called by the *Jews*, and the Antients an Hour. But 15 Degrees of the Equinoctial, do not always aſcend above the Horizon, every one of theſe Hours; but ſometimes more,

more, and ſometimes fewer, as will appear afterward. Therefore, an Hour may rather be defined thus, a certain part of the Artificial Day, and Night, made uſe of by divers Nations, after a divers manner, that it may be known generally, what the Hour is. For in effect, that definition agrees only to to thoſe Hours, which are called *Horæ Æquales*, equal Hours. The Hours then, which are called unequal, ought to be defined thus. The twelfth part of every Artificial Day and Night: therefore according to the divers Seaſons of the Year, the Hours are ſometimes ſhorter, and ſometimes longer: in Summer longer, and in Winter ſhorter, as are the *Jewiſh* Hours; for they divide both the Day, and the Night into twelve parts, both in Summer and in Winter, calling the riſing of the Sun, the beginning of the firſt Hour, and conſequently nine their third Hour; twelve their ſixth Hour, three a Clock in the Afternoon their ninth Hour, and the ſetting of the Sun, the end of their twelfth

twelfth Hour, by which means, their Hours muſt be far longer in Summer, than in Winter.

The equal Hours are of three ſorts: for ſome take their beginning from the ſetting of the Sun, as the *Italian* Hours. Others take their beginning from the riſing of the Sun, as are the *Babyloniſh* Hours, and the Hours of the City of *Norimberg*, who from the riſing of the Sun begin the number of the Hours of the Day; the Circles of which Hours do lightly touch the greateſt Parallels, of all, which do appear above the Horizon, and of all which do not appear. Lastly, Others do take their beginning from the Meridian, which Aſtronomers make uſe of, and theſe Nations, which either take their beginning of Hours from the ſuperior part of the ſame Circle, or from the inferior part.

CHAP.

CHAP. XIII.

Concerning Years.

AS Hours make up Days, ſo Days make up Years, therefore we muſt ſpeak ſomewhat of Years. The Year then is twofold, Aſtronomical, and Political. The Aſtronomical Year, is the ſpace of Time, wherein the Sun returns, either to the ſame Point of the Ecliptick, or to the ſame fixed Star. And this is twofold, the Tropical Year, called *Annus Vertens*, or the Syderial Year. *Annus Vertens*, is a ſpace of Time, wherein the Sun leaving ſome Point of the Ecliptick, returns again to the ſame Point. The quantity of this Year is changeable; for ſometimes it is more, and ſometimes it is leſs. Between theſe two extreams, the middle Year contains 365 days, hours 5, m. 49, ſec. 15. thirds 46. But the true or apparent Year is ſometimes 365 days, hours 5,

min. 56. ſec. 53, thirds 1. Sometime it is 365 days, hours 5, min. 42, ſec. 28, thirds 27. The Syderial Year, is a ſpace of Time, wherein the Sun under the Starry Sky, returns to the ſame fixed Star. The quantity of this Year is 365 days, hours 6, min. 6, ſec. 39. It is always equal to it ſelf, and therefore the meaſure of the Year called *Annus Vertens*. The beginning of this *Annus Vertens*, is taken from the Vernal Equinox, but the beginning of the Syderial Year, from the firſt Star of *Aries*.

The Political Year, is an Annual ſpace of Time, which is either accommodated to the courſe of the Sun, or the Moon, or to both, according to the common reckoning of ſeveral Countries and Nations. This Political Year is manifold; for it is either *Julian*, which contains 365 days, hours 6, which ſix Hours, if they were reckoned every Year, would make confuſion: therefore the Maſters of Aſtronomy have appointed, they ſhould be omitted, till the fourth Year, and then four times ſix, make

make 24, which make up a full and compleat Day, which being *intercaled*, that is, interlaced, or put between, as in Leap Year there is a Day put between the 28 of *February*, and the first of *March*, the Year is called *Annus Intercalaris*, or *Bissextile Year*. It is to be adverted, that the cause of correcting the *Julian Calendar*, by Pope *Gregory* the 13, in the year 1582, was the unjust quantity of it. For by this, it came to pass, that after some Ages, the four Cardinal Points did anticipate and prevent their Seats; and so at length the four Seasons of the Year, might be interchanged. From this it is evident this Day, that according to these times, the Equinoctial, and the Ingress of the Sun into the 12 Signs have anticipated almost 13 Degrees. That is, the entering of the Sun, into *Aries*, *Taurus*, &c. falleth out sooner by 13 Degrees, than to the *Romans*: which comes to pass, because more, than what is just, is given to the space of the Year. For there were given to the Year, by the correc-

ction of *Julius Cesar*, 365 days, and six hours: for which hours, every fourth year, one day is added, and so the common *Julian* year contains 365 days but the *Bissextile* 366. But seing the Solar year, in which the Sun runs thorow the whole Ecliptick, is less than this space, by almost eleven Minuts of Time every Year; it comes to pass, that in 50 year, and a half, one hour remains, and in the space of 130 years, a whole day remains.

I said the Political Year, was manifold, either *Julian*, of which hitherto, or *Egyptian*, or *Judaical*. The *Egyptian* year contains always 365 days. This Year was esteemed most useful by the antient Astronomers, for the Art of reckoning the Celestial Motions. The *Judaical* Year is accommodated and fitted to the Motion of the Moon, and contains, for the greatest part, twelve, and sometimes thirteen Lunations. This Year did the Astronomers use, before the reformation of the Calendar, instituted by *Julius Cesar*, by the help of one

one *Sosigenes*, a famous and learned Mathematician. The beginning of these Years is divers also. For the antient *Romans*, began their Year from *March*: the later *Romans* from the midst of Winter, called *Bruma*. The *Jews*, by Divine Institution, began their Year from the New Moon, which was next after to the Vernal Equinox. That we this day begin our Year from the first of *January*, it is for this, because we following the custom of the late *Romans*, beginning their Year from the midst of Winter, which was neerest to the first of *January*, by little and little the Winter Solstice did prevent, and anticipat its Seat, and Place. The *Egyptian* year, hath not a sure beginning, by reason that six hours are omitted. Hence is it, that every fourth Year it anticipats one Day: and therefore within 365 Years, four times numbered, or 1460 *Julian* Years, the beginning of the *Egyptian* Year, wanders over all the Days of the *Julian* Year.

CHAP. XIV.

Concerning the divers Phenomena, which are to be seen in the various Positions of the Sphere.

THE last part of this little Tractat, shall be in examining the Phenomena, which are proper to the various Situations, and Positions of the Sphere. The Sphere may have seven different Positions, 1. When both the Poles of the World do rest in the Horizon, which is called a Right Sphere. The second Position is Oblique, when our Vertical Point, is terminated between the Equinoctial, and either of the Tropicks. The third Position is, when our Zenith is under either of the Tropicks. The fourth is, when our Zenith is between either of the Tropicks, and the neighbouring Polar. The fifth is, when our Zenith is in the very Polar it self. The sixth is, when our Zenith is between either of the

the Polars, and the neighbouring Pole of the World. And lastly, when the Poles of the World, do fall in with the Poles of the Horizon, which is called a Parallel Sphere.

CHAP. XV.

Concerning the Phenomena of the first Position.

1. EVery Star in the Heavens riseth and setteth, neither is there one of them, without this property: and therefore in this Position, there is neither Polar, Artick, nor Antartick, according to the Antients. 2. There is here a perpetual Equinox. 3. The Sun every Year passing twice over their Heads, is to them twice Vertical, to wit, when he is in the Equinoctial Points. 4. As much, as the Sun declines from their Vertical Point, towards the North, as much also doth he decline from their Vertical

Vertical Point, towards the South. 5. They have four Solſtices, two when the Sun is higheſt in their Vertical Point, and two, when he is loweſt, in *Cancer*, and *Capricorn*. 6. They have two Summers and two Winters, but only Analogically: for even in Winter, their Bodies are ſcorched with heat. 7. There are here in this Poſition, five different Shadows, the Meridional, or South Shadow, the North Shadow, a Shadow from the Eaſt, a Shadow from the Weſt, and a perpendicular Shadow, which falls out only, when the Sun is in the Equinoctial Points. 8. The end or extremity of their Gnomons, upon their Horizontal Dialls, which are our Polar Dialls, deſcribe the whole Year, the Figure called *Hyperbole*, except when the Sun, is in the beginning of *Aries* and *Libra*, where he deſcribes a ſtraight and right Line.

CHAP.

CHAP. XVI.

Of the Phenomena of the second Position.

1. SOme Northern Stars tarrying always above our Horizon, have Eternal Days; and contrariwise, there are some about the South Pole, which never come above the Horizon, but have Eternal Nights. 2. The Artick, and Antartick Circles, according to the Antients, are not as yet equal to our Polars. 3. The Artificial Day is not equal to its own Night, two Days only excepted, when the Sun is in the Equinoctial Points, at which time, there is thorow the whole World an Equinox. 4. The longest Day there, doth not exceed thirteen Hours and a half. 5. The Sun is to them, twice Vertical every Year, to wit, when he comes to those Degrees of the Ecliptick, whose Declination, is equal to the Latitude of the Place; for he describes then, a Parallel

thorow

thorow the Zenith. 6. The Sun in the Meridian, goeth further towards the South, than towards the North. *Note*, That we are now ſpeaking, and in the following Diſcourſe, of thoſe ſeven Poſitions, which are in the Northern Sphere. 7. There are here, four Solſtices, two high, and two low. The two higheſt fall out, when the Sun is in that Parallel, which paſſeth thorow the Zenith. The two loweſt are, when the Sun is in the Tropicks. Yet that which falls out in the Tropick of *Capricorn*, is lower, than that which falls out in the Tropick of *Cancer*. 8. They have two Summers, and two Winters, but unequal, as appears from the various Situation of the Parallels. 9. The longeſt Day is not, when the Sun is in the higheſt Solſtices, but in the Tropick of *Cancer*. 10. There are five different Shadows, as we obſerved in the firſt Poſition. 11. The end or extremity of the Gnomon, by its Shadow, when the Sun is out of the Equinoctial, deſcribes (as in the firſt Poſition) the

Figure

Figure called *Hyperbole*, but the opposite sides are not equal as there, but unequal. 12. In any part of this Position, where the Elevation of the Pole, is less, than the Declination of the Sun, the Shadow of a Style perpendicularly erected upon a Plain, may have a natural, visible, Retrocession. In the matter of *Abaz* his Dial, the Retrogradation of the Shadow was miraculous, because it was done without, and not within the Tropicks, neither is it possible in nature, it can happen, but where the Elevation of the Pole, is less than the Suns Declination, which is only within the Tropicks. But the foresaid Dial was placed far without, to wit, under the Latitude of 35 Degrees.

CHAP.

CHAP. XVII.

Of the Phenomena of the third Position.

1. ALL the Stars, which are comprehended within the North Polar, remain always above the Horizon, neither do they ever set, unless it be, by a general setting *Heliace*; and contrariwise, all the Stars, which are comprehended within the South Polar, have a perpetual Night: therefore the Polars, according to the Antients, are now equal to our Polars. 2. The longest Artificial Day is, when the Sun passeth over our Zenith; the shortest, when the Sun is fartheſt in the Meridian removed from it. 3. Once a Year only is the Sun Vertical, to wit, when he is in the beginning of *Cancer*. 4. The Sun in the Meridian, never descendeth from the Zenith towards the North, but returning from the Tropick of *Cancer*, he is alway in the South. 5. There

are

are here, but two Solſtices, one high, another low. The higheſt, when the Sun is in the Tropick of *Cancer*; the loweſt when the Sun is in the Tropick of *Capricorn*. 6. The Day is longeſt, when the Sun is in the Tropick of *Cancer*, it is ſhorteſt when the Sun is in the Tropick of *Capricorn*. 7. There is one Summer, when the Sun is in the Zenith, and one Winter, when he is in the Winter Solſtice. 8. They have four different Shadows, one Perpendicular, one Oriental, one Occidental, and one Meridional. Here begin the *Heteroſcii*, for the Meridional Shadows begin there to decay, that is, the Shadows projected towards the South. 9. The extremity or end of their Gnomon, upon their Dials, deſcribe alſo the Figure called *Hyperbole*, the ſides oppoſite being unequal.

CHAP.

CHAP. XVIII.

Of the Phenomena of the fourth Position.

AS the Artick and Antartick of the Antients, are greater than our Polars, ſo there are more Stars in this Poſition of the Sphere, ſeen perpetually, and more perpetually lurking under the Horizon, than in the laſt Poſition. 2. The unequality of Days and Nights, are alſo augmented. The Artificial Day is at the longeſt, when the Sun comes neareſt to our Zenith, and at the ſhorteſt, when he is furtheſt removed from it: and as the ſhorteſt Artificial Day cannot be leſs, than 13 Hours and a half, ſo the longeſt Day cannot be 24 Hours. This leaſt Artificial Day, is truly the longeſt Day, our Vertical Point coming neareſt to the Tropick. It is called the leaſt Artificial Day; becauſe it is the ſhorteſt of all the longeſt Days, which can ariſe from the variation of the

the Vertical Point, between the Tropick and the Polar: and therefore, it is not called *Minima* the leaſt, in reſpect of the reſt of the days of the ſame Elevation of the Pole, but in reſpect of the reſt of the longeſt Days, which may be found between the Tropick and Polar. The longeſt Day in this fourth Poſition of the Sphere, the Zenith coming neareſt to our Tropick, cannot be leſs, than 13 Hours and a half, as the longeſt Day cannot contain 24 Hours. For this comes to paſs, when the Zenith is in the Polar: therefore we muſt read, as *the ſhorteſt Artificial longeſt Day, cannot be leſs, than* 13 *Hours and a half*, &c. 3. The Sun can never come to their Zenith, neither can he ever touch lightly (*ſtringere*) their Horizon, when he is in the Meridian. 4. There are two Solſtices, one when the Sun is in *Cancer*, and higheſt, another loweſt, when he is in the Tropick of *Capricorn*. 5. There is one Summer, and one Winter. 6. There are only three different Shadows, one Oriental, the ſecond Occidental, and the

the third Northern. 7. The extremity or end of their Gnomons, fixed upon the Ground perpendicularly, describe as yet *Hyperbolæ*.

CHAP. XIX.

Of the Phænomena of the fifth Position.

ALL the Stars, whose distance from the Equinoctial, is greater than the Obliquity of the Ecliptick, either do not set under the Horizon, if they be Northern Stars, and do not rise above the Horizon, if they be Southern Stars: Therefore the Artick, and Antartick of the Antients are equal to the Tropicks. 2. The longest Day contains 24 Hours, and then there is no Night: and contrariwise, the longest Night consists of twenty and four Hours, and the Artificial shortest Day is nothing. 3. The Sun every year toucheth lightly the border of the Horizon twice, without rising and setting, namely when he is in the

the Tropicks. 4. The Sun at twelve a Clock in the Day, is alwayes South, nevertheless, when he is in the Tropick of *Cancer*, the half of his Body may be seen in the North, at 12 a Clock at Night. 5. There are here two Solstices, one high in *Cancer*, the other low in *Capricorn*. But according to the similitude of Solstices, which are in other Zones, we may say there are three Solstices there, one high in *Cancer*, when the Sun is high in the Meridian, to wit, 47 Degrees above the Horizon, which is the distance of the Tropicks; there are two lower, of which one is in the same Tropick of *Cancer* towards the North, when he toucheth lightly the border of the Horizon, the other in the Tropick of *Capricorn*, where he also lightly toucheth the border of the Horizon. 6. There is one Summer, and one Winter. 7. There are four different Shadows; one Eastern, one Western, one Northern, and one Southern; tho this happens but once a Year, the Sun shineing with the half only of his Rays, which

makes the light more obscure and dark, than when he shines with his full Rays. Here begin the *Heteroscii*. 8. The extremity or ends of the Gnomons, describe the Figure called *Parabola*, upon the Horizontal Dials, but an *Hyperbole*, so soon, as the Sun is gone from the Equinoctial, whereas on all other Plains, he describes always straight and right Lines.

CHAP. XX.

Of the Phenomena of the sixth Position.

THere are very few Stars, which can rise or set, to wit, those only, whose Declination is less than the distance of the Tropicks; because the Artick, and Antartick Circles, comprehending within them, the Stars which do set, and do not set, are greater than the Tropicks. 2. They have an Equinoctial, as other parts of the Earth. But when the Sun is in that Parallel whose

whose Declination from the Equinoctial, is equal to the distance of the Poles of the World from the Zenith, the Day is twenty and four Hours, and the Artificial Day excreseeth, and shoots out, into many Natural Days. 3. The Sun being in the same Parallel, he lightly toucheth, the border of the Horizon, and coming to it, she shines only with an half Orb. 4. They have but only one Solstice, in the Tropick of *Cancer*; for the other in the Tropick of *Capricorn* cannot be seen. But Analogically, and in similitude there are six Solstices. Two high, when the Sun is in the Tropick of *Cancer*: for there, as well to the South, as to the North, the hight of the Sun in the Meridian is highest, although the Northern be greater than the Southern: and four lowest, when the the Sun toucheth lightly the Horizon. 5. They have one Summer, and one Winter, but their Summer may be so called only Analogically: for these places of the Earth, are perpetually stiff with Snow and Yce. 6. They have

four different Shadows, one from the East, one from the West, one from the South, and one from the North. Here are the *Periscii*. 7. The Gnomons, and stiles of their Dials, describes with their Points, Elliptical Figures.

CHAP. XXI.

Of the Phenomena of the seventh and last Position.

1. THere are here no Stars, which either rise or set, but all of them are whirled about, equally distant from the Horizon. The Artick and Antartick Circles, are one and the same with the Horizon, and Equinoctial, which are now united. Understand this of the fixed Stars only; for the Planets, absolving their course, rise and set, in their appointed times. 2. The Artificial Day is extended to half a Year; so is the Artificial Night, and therefore the quantity of the Natural Day, and the

the whole Year is one and the ſame. 3. When the Sun is in the Equinoctial, he ſhines only with half his Orb, and toucheth lightly the Horizon, and there he riſeth and ſetteth only at thoſe times. 4. No point of the Heavens, can be called, either Weſt, Eaſt, South or North, ſeing the Pole of the World doth not incline to any part of the Horizon, by which Inclination the four Points of the Univerſe, have their diſtinction. 5. They have only one Solſtice, to wit, in *Cancer*, but Analogically two other may be added, to wit, when the Sun is in the beginning of *Aries*, and *Libra*. 6. There is one Summer and one Winter: but their Summer is rather to be called a ſlender ſlaking of the Cold. They have one Winter, becauſe the Sun is under their Horizon a whole half Year together. 7. The Gnomons of their Dials, deſcribe with the extremity of the Shadow, upon an Horizontal Plain, perfect Circles.

FINIS.

Proteus Bound with Chains:

OR,

A Discovery of the Secrets of Nature, which are found in the Mercurial-Weather-Glass, unfolding the Reasons, and Causes, why before Fair Weather the Quicksilver Ascends, and before Foul Weather, it falls down, and Descends.

A Subject not hitherto Treated of.

TOGETHER

With some brief Observes upon the *Parisian* Weather-Glass, and an Explanation of the Sealed Weather-Glass, and common Weather-Glass.

To all which is Added

The Theory of the Weather, according to the Perpendicular Weather-Glass.

By *GEORGE SINCLAR*, sometime Professor of Philosophy in the Colledge of *GLASGOW*.

Felix qui potuit rerum cognoscere causas.

Edinburgh, Printed by the Heir of *Andrew Anderson*, Printer to His most Sacred *Majesty*, Anno *Dom.* 1688.

1264.19

Proteus bound with Chains:

OR,

A Discovery of the Secrets of Nature, which are found in the Mercurial Weather-Glass, *&c.*

THere are many excellent Questions to be Resolved, and Causes of the various Phenomena of Nature to be rendred, before a man can have knowledge to mount the *Mercurial-Weather-Glass*. Yet there are many, who rashly adventure, and bring upon that unerring and infallible Master-piece of Nature, the scandalous and odious Character of Fallibility, either by raising the *Mercury* too high, or fixing it too low in the Cylindrical-Glass, both which Extreams must

muſt be cautiouſly ſhunned. For if it be not ordered according to the Authentick Obſervations of the Weather for many Years paſt, it cannot but err. And herein its infallibility and perfection conſiſts, to give the Theory of the Weather a juſt and determinate hight, according to long Obſervation, and by conſequence the top of the Cylinder the ſame hight, none of which no ignorant perſon can do. The Queſtions to be reſolved, are ſuch as follow. 1. What ſuſtains the Mercury in the Glaſs-Tube, whilſt the Orifice is always downward, and open? 2. Why the Glaſs muſt exceed in length, one and thirty Inch? 3. Why the Mercury falls not down, if it be ſhorter than twenty and eight? 4. Why the Mercury is carried up with violence to the top of the Glaſs-Tube, whilſt the Orifice is raiſed above the ſurface of the ſtagnant Mercury? 5. Why as much Mercury in hight, is ſuſtained in the wide Glaſs, as in the narrow? 6. Why, tho the Glaſs were in hight many Foot, yet the whole Mercury falls down

down to twenty and nine, or thirty Inch above the Ciſtern? 7. What fills up the ſpace left empty behind? 8. Why the Mercury ſubſides by degrees, as the Weather-Glaſs is carried up ſome high Mountain, and why it riſes again, as it is carried down? 9. Why a Glaſs of thirty ſix Foot high is required to make a Weather-Glaſs with Water in it? 10. What's the reaſon, I do not find the weight of the Mercury within the Glaſs, whilſt I poiſe it between my Fingers, and yet I find another weight exactly the weight of it? 11. What that other weight is? All theſe and many more are fully and clearly reſolved in my *Philoſophical Experiments* twenty years ago.

But there is a late Queſtion, which troubleth all the Learned to reſolve, which now I intend ſhortly to explain, *viz.* What's the reaſon, why the Quick-ſilver in the Weather-Glaſs creeps up before Fair Weather, and falls down before Foul Weather? For an anſwer to this conſiderable Queſtion, it is to be obſerved,

muſt be cautiouſly ſhunned. For if it be not ordered according to the Authentick Obſervations of the Weather for many Years paſt, it cannot but err. And herein its infallibility and perfection conſiſts, to give the Theory of the Weather a juſt and determinate hight, according to long Obſervation, and by conſequence the top of the Cylinder the ſame hight, none of which no ignorant perſon can do. The Queſtions to be reſolved, are ſuch as follow. 1. What ſuſtains the Mercury in the Glaſs-Tube, whilſt the Orifice is always downward, and open? 2. Why the Glaſs muſt exceed in length, one and thirty Inch? 3. Why the Mercury falls not down, if it be ſhorter than twenty and eight? 4. Why the Mercury is carried up with violence to the top of the Glaſs-Tube, whilſt the Orifice is raiſed above the ſurface of the ſtagnant Mercury? 5. Why as much Mercury in hight, is ſuſtained in the wide Glaſs, as in the narrow? 6. Why, tho the Glaſs were in hight many Foot, yet the whole Mercury falls down

down to twenty and nine, or thirty Inch above the Ciſtern? 7. What fills up the ſpace left empty behind? 8. Why the Mercury ſubſides by degrees, as the Weather-Glaſs is carried up ſome high Mountain, and why it riſes again, as it is carried down? 9. Why a Glaſs of thirty ſix Foot high is required to make a Weather-Glaſs with Water in it? 10. What's the reaſon, I do not find the weight of the Mercury within the Glaſs, whilſt I poiſe it between my Fingers, and yet I find another weight exactly the weight of it? 11. What that other weight is? All theſe and many more are fully and clearly reſolved in my *Philoſophical Experiments* twenty years ago.

But there is a late Queſtion, which troubleth all the Learned to reſolve, which now I intend ſhortly to explain, *viz.* What's the reaſon, why the Quick-ſilver in the Weather-Glaſs creeps up before Fair Weather, and falls down before Foul Weather? For an anſwer to this conſiderable Queſtion, it is to be obſerved,

observed, that in the fouleſt Weather, I have found the Quickſilver fall down to twenty and eight, and in the dryeſt, and faireſt Weather, I have found it up at thirty and one Inch. From this excellent Phenomenon only, it is called the Weather-Glaſs, *Kat'exohen*, by way of excellency: becauſe before this alteration was found in it, it was called by the moſt part of Philoſophers, *the Torricellian Experiment*.

For clearing the Queſtion in hand, I ſuppoſe that in the Beginning, there went up a Damp from the Earth to water the whole face of the Ground. *Moſes* (*Gen. 2.*) relates now the ordinary means appointed by God in Nature, for bringing forth of Herbs, Buſhes, and Trees out of the Ground, *viz.* the Damp, which cauſeth the Rain, and moiſtneth the Earth, which Damp being by the heat of the Sun rarified, aſcendeth to the middle Region of the Air, where by means of the coldneſs thereof, theſe Vapors are condenſat, and thickned, and turned into a Cloud, and afterward

afterward are turned into Rain, and so fall down.

That there are such Damps and Vapors, which ascend from the Earth, and Waters, cannot rationally be denyed; nay many Thousands and Millions of them ascend, which we do not see, nor observe. I have seen in Frosty Mornings the mouths of Coal-sinks, and empty passages from waste Ground, where Coals have been digged out, Fumes and Vapors coming out so plentifully, as Fumes from a Salt-pan. Some do fitly compare this Earth to a Bag-pudding, taken out of a Boiling-pot, which sends forth Vapors in abundance. Likewise from the surfaces of standing and running Water, what numbers may be seen in a warm Summers Evening. Nay from the Bodies of Men and Beasts, there is a perpetual Perspiration. But the finest and purest of all, are those which are exhaled from the Earth, and Waters. We see, that when the Sun is hot in Summer, the whole face of the Ground after Rain, covered over with Undus,

or

or little curled Waves, a ſmall Gale of Wind being ſtirring, like unto the curled Waves of the Sea, Analogically. And ſo ſlender and pure are they, that whilſt a man is among them, he cannot ſee them, but at a diſtance he may, looking alongs the face of the Ground. Likewiſe what multitudes of them may be ſeen alongs the ſurface of the Sea, a man ſtanding at a conſiderable diſtance from the Coaſt. And ſo thick are they, that they have wonderfully lifted up, and magnified, much of the Land, and have made it appear, far otherwiſe than it was; nay, eclipſed whole Villages and Towns, and metamorphoſed them into various ſhapes and forms, all which have come to paſs, by reaſon of their multiplicity and thickneſs. Now theſe Vapors, flowing from the Earth and Waters, are carried up to the middle Region of the Air, where by proceſs of time, they are condenſat, and thickned, by the coldneſs thereof, and fall down in Rain.

But here it may be inquired, By what

what cause, or power, are these Vapors carried up, seing they are Material things, and endued with weight? For answer, I must premit some few things, which do not ordinarly occur. First, That in all heavy Bodies, there is a twofold weight, one Specifical, the other Individual. The Specifical weight is found in Bodies, which differ by Nature, as Wood, and Stone, ballanced one with another, equal quantity with equal quantity. Individuall weight, is likewise found in the same Bodies, but after a different way and manner. For example, Stone is naturally, or specifically heavier than Wood, putting equal quantity against equal quantity; for a Cubical-foot of Stone, is heavier, than a Cubical-foot of Water. Bodies of the same Individual weight, or such as are weighed in a pair of Scales, as a Pound of Lead, and a Pound of Wool, are individually of the same weight, but of different weight Specifically. Secondly, There are two sorts of Ballances, the one Natural, the other Artificial.

The

The Natural Ballance, is the *Mercurial Weather-Glass*, wherein the Mercury counterpoiseth the Air, and the Air the Mercury, both of them observing an equal Altitude, according to their natural weights: for since the Mercury is reckoned 14000 times heavier than the Air, the pillar of the one must be 14000 times lower than the other; and so both are of the same hight, according to their Specifical weights. The Artificial Ballance, is that Mechanical Power, called the *Libra*. Thirdly, That one Body naturally lighter than another, may become of equal weight, or heavier, than that other. For example, the Vapors, which ascend are far lighter specifically, than the Air, yet they become heavier specifically, when contracted, and reduced by a Cold, to a thicker habit, or consistency, and most of all when they are converted to Rain. But how shall it be known, that the Vapors are naturally lighter, than the Air? I answer, If it were possible to take an equal quantity of Vapors, with an equal quantity

of

of Air, and weigh them in a Ballance, the Air would be heavier. We know that Oil is lighter than Water, for being put under Water, it riſeth to the Surface: ſo the Vapors go up thorow the Air, as Oil goeth up thorow the Water. Now I come to the Queſtion in hand, and I affirm, that the Vapors are carried upward, not by the heat of the Sun, which is an vulgar error, but they being ſpecifically, and naturally lighter, than the Air, are preſt up by it, as Smoak, till they come ſo far up, as the preſſure of the Air, is able to carry them. I ſhall make this evident, by the following Experiment. Let a Diver go down to the bottom of the Sea, with a Bottle of Oil in his Hand, and pour it out there, he ſhall find, that ſuch is the preſſure of the Water, it ſhall drive it all up to the Surface above. For as the Oil is naturally lighter than the Water, ſo theſe Vapors are naturally lighter than the Air. Now theſe Vapors, which are infinite in number, aſcending from all the parts of the Earth, to the Atmo-

ſphere many Miles above the Clouds, cauſeth the Air here below preſs with greater weight, upon the ſtagnant Mercury, and ſo raiſeth the Quickſilver in the Weather-Glaſs, one Inch or two, and ſometimes three: for it is not poſſible, that the Air above, can be preſt down, and burdened, with that new weight, and addition of Vapors aſcending, but the ſtagnant Mercury below muſt find the ſaid preſſure.

But how are theſe Vapors condenſat and thickned togeither, and fall down in Rain? I ſhall do this, by a moſt evident, and clear example. We cannot more fitly compare theſe Vapors, aſcending and deſcending again in Rain, than to an Alembick, or Diſtillater. For theſe Fumes being carried upward within the Pot, and meeting with a cold Receptacle (for the Pipe deſcending goeth ordinarly thorow a Veſſel full of cold Water) they are preſently reduced, to their firſt condition, and fall down in Liquor. So are the Vapors, which aſcend

aſcend from the Stomach to the cold Brain received and diſtilled.

But why ſhould the falling down of the Rain cauſe the Quickſilver fall down, and why ſhould the riſing of the Vapors, cauſe the Quickſilver to riſe? For clearing of this, it is to be adverted, that whilſt the Mercury is up at one and thirty Inch, there is an equal ballance or weight between the weight of the Atmoſphere and the weight of the Quickſilver, ſo that there cannot be the leaſt weight ſubtracted from the preſſure of the Atmoſphere, but as much muſt be ſubtracted, from the hight of the Quickſilver: as by taking away one Ounce from this Scale of a Ballance, the other preſently goeth down, or by adding one Ounce to this Scale of a Ballance, the other Scale preſently goeth up. Hence is it, that the preſſure of the Atmoſphere becomes leſs, by the falling down of the Vapors, and conſequently the hight of the Quickſilver, muſt decreſce alſo. And contrariwiſe (which clears the ſecond part of the

Queſtion) whilſt the Vapors are aſcending, and going up, the Atmoſphere is more burdened, and by conſequence the Quickſilver riſeth, ſometimes leſs, and ſometimes more, ſometimes one Inch, ſometimes two or three.

But how comes it to paſs, that the whole Air, or that great and vaſt bulk of it, can be in equal weight, with ſo ſmall a portion of Quickſilver, granting the Air to be ſo heavy, as is commonly reported? I anſwer, It is not the Air according to its thickneſs, or bulk, which makes any counterballance with the Quickſilver, but it is the Air reckoned according to hight, becauſe Fluid Bodies do not counterpoiſe one another, according to all their dimenſions, but only according to Altitude; this is only proper to Solid Bodies. For let never ſo much weight be added to the Air in thickneſs, itſhall never make the leaſt alteration in the Mercury. But if there be but the leaſt addition made in hight, the Quickſilver preſently knows it, by riſing and falling accordingly. For by how many thou-

ſand

ſand times the Air is ſpecifically lighter than Quickſilver, by ſo many thouſand times is the pillar of Air, higher than the pillar of Quickſilver. And contrariwiſe, by how many thouſand times the Quickſilver is naturally heavier than the Air, by ſo many thouſand times muſt the Cylinder of Quickſilver, be ſhorter than the Cylinder of Air, which ſuſtains it. The proportion is ordinarly reckoned as 1 to 14000. That is to ſay, one Cubick-Inch of Quickſilver counterpoiſeth 14000 Cubick-Inches of Air, both being put into a Ballance.

It is evident from this, and many other things, that there is a proportion obſerved in all the Works of Nature, as here between the hight of the Atmoſpere, and the hight of the Quickſilver: for all the Lords Works, are made in Weight, Meaſure, and Number. This truth is ſo evident in the Mathematical part of Learning, that there is no need of proof. And if this proportion be not obſerved in things Artificial, *viz.* by Architects and Builders of Houſes, the

whole Fabrick looks pitifully, and wants that face, and delicate aspect, it ought to have. And as the most wise *Artist* of the World, hath created all things in proportion one to another, so all the parts of his Holy Word, are in such a proportion one to another. For this we have Scripture, and Divine Authority: for it is said, *Whether we prophesie, let us prophesie according to the proportion of Faith.* The Original word is, *Analogia Pisteos*, well rendered in our Vulgar Language, *the proportion of Faith*, or *Analogy of Faith*, not as some, *the Measure of Faith.*

GOD is not tied to Numbers, yet nevertheless, he doth and disposeth his Works, by Number, Weight, and Measure. It is observed, that after the going up out of *Egypt*, GOD caused to be numbred all the *Israelites*, from the Age of twenty years and upward, (*Exod.* 38. 26.) and there were found six hundred three thousand five hundred and fifty men. The year following, GOD commanded to make a second Review

of the People, (*Numb.* 1. 46.) but without comprising the *Levites*, which had been numbred the first time with the other Tribes. Notwithstanding this Subtraction, and the Casualities, which might have changed the number of the People, since the year foregoing, it is found that their number was yet justly and precisely six hundred three thousand five hundred and fifty men. In which is seen a proportion which GOD held in the multiplication of that People. There is also observed a Mystery in the exact number of the two and twenty thousand *Levites*, which were then reckoned (*Numb.* 3. 39.) For the rest, I contend not against the common opinion, touching the hundred fourty and four thousand of the seventh of the *Revelation*, that they ought to be taken for an indefinite number, as well as the seven thousand which had not bowed the Knee to *Baal*. But it ought to be considered, why the Holy Ghost, who speaketh nothing superfluous, is not contented to have named the total sum of them,

them, that were ſealed in *Iſrael*, but alſo divideth it, in twelve times twelve thouſand, diſtributed by equal portions among the twelve Tribes, every one of which is mentioned, the one after the other, with the expreſſion of its particular number: for this ſheweth, that the number of the Elect, and the multitude of Believers, are meaſured by certain proportions, which are known to him, who is the Author. Certainly, the reſemblance of the ſeventy Diſciples of Chriſt, to the ſeventy Judges, which were ſubſtituted to *Moſes*, and to the ſeventy Children, which *Jacob* had when he went down into *Egypt*, is a line of this admirable Symmetry, with the which God hath limited, and proportioned the Body of the Church.

Now this fortifieth that Maxime, that the number of the Elect cannot ſuffer addition, nor diminution: and that Election proceedeth not, from the Will of the Elect, but that of God, which prevented them. For it cannot be ſaid, that all the Elect, from the beginning

of

of the World to the end, have agreed together to make a Company composed precisely of a number certain and regular.

But I return. It may be here inquired, Whether those Vapors, and Exhalations go perpetually up from the Earth, or not? 'Tis probable, that they are alway ascending, tho insensibly to us, and as many of them in the Night, as in the Day-time. Nay, more (it seems) in extream Frost and Cold Weather, than at any other time; as we see in *Greenland*, where the greatest extremity of Cold is, there are infinite Treasures of Snow, which Snow could not fall down so plentifully, if there were not Vapors perpetually ascending. Next, after Rain, and the falling down of the Mercury to 28, or 29 Inch, I have found the ascent of it, in that same Night eight or ten Degrees, which could not happen, unless there had been an addition of new weight to the Atmosphere. And this is observed, to be rather in the Winter, than in the Summer Season, especially in calm Nights. I have observed, that

that the next Morning after Frost all the Night, the standing Waters in Furrows, which have remained many Days entire, dry up, and nothing remaining, but emptiness below a surface of thin white Yce. This Water could not sink into the Ground, more that Night, than many others before; but the Frost coming on, and the Air becoming dry have turned all the Waters into Vapors, and so have been exhaled.

I would have it made more evident, how the greater pressure of the Atmosphere by the weight of these Vapors make the Quicksilver rise in the Weather-Glass? I answer, Take the Weather-Glass, and place it within a dry Harbour, before the Water begin to flow. Then suppose the hight of the Mercury to be eight and twenty Inch. I say, when once the Water hath flowed, but three Foot and a half in hight, above the stagnant Mercury in the Cistern, you will find the Mercury in the Weather-Glass three Inch higher. For as the growing of the Tide above the stagnant Mercury

Mercury raiſeth it higher, and higher in the Glaſs, ſo the aſcending of the Vapors loadneth the Atmoſphere, more and more, and conſequently it preſſeth with more weight upon the Mercury in the Ciſtern. And as the Vapors are turned into Rain, and the Mercury falls down; ſo by the ebbing of the Water, the three Inch of Mercury, falls down within the Weather-Glaſs.

It may be inquired, How far do theſe Vapors aſcend? I anſwer, That Philoſophers diſtinguiſh the Air into three Regions, the firſt, ſecond, and third. But both Philoſophers and Aſtronomers do vary exceedingly in determining the hight of any of them. I ſhall not curiouſly inquire, but ſhall ſpeak a little to what concerns the preſent purpoſe. 'Tis probable, that theſe thin and light Vapors, which flow out of the Earth and Waters, go many Miles above the Clouds, where there is neither Wind nor Rain: for the preſſure of the Air being powerful many Miles up, muſt carry the Vapors, ſo far up. But to determine

termine particularly, it is not possible, only in general they ascend very far. Now it is evident, that the Atmosphere, is composed, and consists of such Vapors being called *Sphæra halituum*, which no doubt, is of a considerable thickness, and hight. These Vapors, when they are once past the inferior Region of the Air, which will not exceed an *English* Mile, and a half, go up quickly, and are received by the Atmosphere, where they accresce to a considerable hight, perhaps 40 or 50 Mile above the Clouds, where by some extrinsick cause, as extremity of Cold, they fall down from the Atmosphere, first as Mist or Dew, till they come to the lowest Region, where in a very short time, they cover the whole Heavens, tho never so clear before. How many times before Rain, will this be seen.

Besides, there is above the Atmosphere, that which Astronomers call the *Diluculum* and the *Crepusculum*, that is, both the Dawning of the Day, and the Twilight in the Evening, the one beginning about

about two Hours before the Sun riſe, and the other ending about two Hours after the Sun is gone down. For if that *Crepuſculum* were not there, we ſhould have no Light, until the Body of the Sun were above the Horizon, and ſhould have no Light after the Body of the Sun is ſet. This Sphere is unalterable, and without accreſce or decreaſe, but the Atmoſphere is not ſo, by reaſon of the Vapors coming to it, and decreaſing again. Next, the Refraction, which makes the Sun or Star to appear above the Horizon higher, than really it is, is cauſed by the Atmoſphere. 'Tis obſerved by Shepherds, that if the Sun appear ſooner above the Horizon, than ordinary, the Day following ſhall be Rainy. They ſee indeed the Image of the Sun, a little before he riſe, which is cauſed by the Refraction, or thick *Medium* of the Vapors, which ly about the Horizon. For example, Let a man ſo fix his Eye, upon a wide Veſſel, with an open mouth, with a piece of Money in the bottom, he ſhall not ſee it, till the

the Veſſel be fill'd with Water. For Water being a thick *Medium* raiſeth the Image of the Money, and brings it to the Eye by a broken and crooked Line, which is *Radium refrangere*, or rather *refringere*.

It may be further inquired, Why the Clouds are ſuſtained, or what keeps them up from falling down? This is a conſiderable Queſtion, and well worthy of a Divine Anſwer. The Lord ſays to *Job*, *Daſt thou know the ballancing of the Clouds, the wondrous works of him who is perfect in Knowledge?* The Clouds then are ſuſpended, not miraculouſly, yet wonderfully by Natural Cauſes; for as a Ship is ſuſtained from ſinking by an even Ballance with the Water, ſo are the Clouds keeped up, by an even and equal Ballance with the preſſure of the Air, which really ſuſtains them. If they be light and thin, they go further up, but if they be heavy and black, they come nearer to the Earth, but are ſtill in an equal Ballance, with the preſſure of the Air. And as the Loadned Ship

goeth

goeth further down in the Water, than the Ship, that's not burdened; so do the black and heavy Clouds swim lower, than the light and white Clouds. But when there is a great convocation of Clouds together in one place, each one presseth upon another, and so like Honey-Combs they distil their Drops upon the Earth. *Note*, That the greatest Ship in *Europe*, with all her Furniture for War, is but the just and exact weight of the Water, thrust out of its place by the Ships Water-draught.

It may be yet inquired, How far are these Clouds from the Earth, which send down the Rain? I answer, The surest way to know, is by the Thunder. Observe then, how many Seconds of Time, do pass, between the first seeing of the Glance, and the hearing of the Crack. If the Noise be straight up, five or six will pass, which make an *English* Mile. In Mountainous Ground, which lyeth higher, three at the most will interveen, about five hundred pass. To know exactly a Second of Time, whereof 3600

make

make an Hour, follow this method. Take a ſmall Chord of thirty and ſeven Inch and a half exactly. To which append a Lead-bullet of ſeven or eight Ounce. Hang it ſo, that it may ſwing to and fro of its own accord. Each one of theſe Swings are a *Second* of Time.

But may it not be affirmed, that the greater preſſure of the Air, which raiſeth the Quickſilver, is cauſed by the weight of the Clouds, which ſwim above us: and that the falling down of the Quickſilver is cauſed by the diſſolution of theſe Clouds into Rain? I anſwer, This cannot be: for when the Heavens are moſt ſerene and clear, the Mercury is furtheſt up; and when the Heavens, are nubilous, and covered with Clouds, the Mercury many a time is furtheſt down.

It may be inquired, Whether the cracking of Thunder, maketh any alteration upon the Weather-Glaſs? I anſwer, There are three things to be conſidered in Thunder, Firſt, The Lightning. Secondly, The Crack. Thirdly,

lyes The Thunder-bolt: which three are lively represented to us by the shooting of a Cannon; for the Fire coming out of the Muzzle, represents the Lightning; the Report, represents the Crack; and the Bullet, the Thunder-bolt. But there is a more lively representation of Thunder, in *Aurum fulminans*, which like the Thunder-bolt carrieth its stroak downward, three Grains of which, tho never so little made hot, takes Fire, and gives a greater Report, than two Ounces of Gun-powder, so stupendious is it. But there is nothing here, which can make any alteration upon the Weather-Glass.

It may be inquired, If the Winds make any alteration upon it? I answer, Winds are nothing but Air agitated; nor Tempests, but Air-floods, or violent Agitations of the Air. These do really influence the Weather-Glass, not only in causing the Quicksilver subside, and fall down, but in causing the top of the Mercury tremble, and make some visible reciprocations up and down, e-

ſpecially when the Wind blows very high. Next, Winds which come from the South and South-weſt, by reaſon of much moiſtneſs, which they bring alongs with them, influenceth the Quickſilver much indeed. But Northerly Winds, which are more drying, have leſs influence. Nay Eaſterly and North-eaſt Winds even with Rain, keep up the Mercury, and ſuffers it not to fall down ſo far, as other Winds. Becauſe ſuch Winds come from the *Great Continent*, bringing with them many Earthly Particles, and Atoms, which being dry, have not that influence upon it, as moiſt Winds from the South and Weſt.

It may be inquired, If the Weather-Glaſs doth foretell Winds, as it doth Rain? I anſwer, It doth not ſo much foretell Winds, as it is actually influenced by them. Yet, if a man were a diligent Obſerver of the Winds, before they blow, and took narrow inſpection of the Weather-Glaſs, he would ſurely foreſee them approaching, by ſome alteration or other in it.

It

It may be inquired, Whether Mist or Fog doth affect the Weather-Glass? I Answer, Yes, for I have observed, when the Mercury has been up at *Fair*, the falling down of a Fog, hath brought it down three or four Degrees.

It may be inquired, When the Mercury is at the highest Station, in the fairest Weather, as above *Long Fair*, how many Days doth it prognostick Rain, before it come? I Answer, When it first begins to alter, it must fall down to *Long Fair*, half an Inch; next to *Fair*, another half Inch. Thirdly, To *Changeable*, as much: And lastly, To *Rain*. This Motion is slow, and therefore it foretells, sometimes three Days, sometimes four, sometimes less. But this is sure, it cannot fall down in one Day so much bounds, nor in two, neither in three. I have seen it fall down from *Long Fair* to *Fair*, and then halt, by reason of some stirring Winds, or by reason, of some small change of Weather, in some County near hand. When it's far up, as at *Long Fair*, or

above it, it is next to impossible, that either Wind or Rain can be.

Some, who are not acquaint with the Weather-Glass judge it erring, when they see the Mercury at *Rain*, and yet no Rain. I confess it may be so, if it be not rightly adjusted, at the first letting up; but if it be set, according to Art, the Mercury cannot be at *Rain*, but there must be Rain, either here, or some place near hand.

It may be inquired, If Snow and Hail have the same effects upon the Weather-Glass, which Rain have? I answer, Yes; for they are both from the same cause, namely moist Vapors. I have seen the next adjacent Hills covered with Snow, when there was neither Rain nor Snow in the Valley Country, and the Mercury down at *Rain*, tho it had been always up before the Snow fell. And many times it is found, that Rain falling in the next Shires, or Counties, tho none here, have made the Quicksilver fall down to *Rain*. The last year 1687, in *November*, I have seen the

Quicksilver,

Quickſilver, below *Much Rain*, and yet the Days going before, or following, have been pretty fair. But the Weather, was under a ſtrong diſpoſition, and inclination to be Tempeſtuous and Stormy, which ſoon followed. 'Tis obſervable, that the Quickſilver, is never ſo high in the Weather-Glaſs, as about the hinder end of the Month of *October*, or rather in the Winter Seaſon. In Rainy Years, I have not ſeen the Mercury further up than *Fair*, and that ſeldom.

Might the Weather-Glaſs be uſeful in Ships? I anſwer, Yes; but the commotion of the Ship, (you ſay) renders it uſeleſs. I anſwer, it might be ſo ſuſpended, that it might hang always perpendicular. And tho this were not, yet the Nature of it is ſuch, that it can recline without hurt, as much as the Ship can ly, either to Starboord, or Larboord, and fall right again, when the Helm is righted. In a word, whatever advantage a man might have by it,

in his Chamber, he may have as much, by having it in his Cabin.

There is a perſon of Honour, and great Learning, who hath written lately in *Natural Philoſophy*, and among other things, hath not omitted to ſhew the reaſon of this marvellous Phenomenon, whereof I have been Treating. He toucheth it briefly in 9 or 10 Lines, and ſays, *Id autem mirum ſatis videtur*, &c. 'Tis a ſtrange thing (ſays he) that in Rainy and Windy Weather, when the Air ſeems to be heavieſt, yet the Mercury is furtheſt down. The reaſon (ſays he) is taken from the temperament of the Air, where the Clouds are; for when the Clouds are groſſer, tho much elevated, they intercept the Rays of the Sun, and are thereby melted, and turned into Rain. And the Air being eaſed of the burden of theſe Clouds, and being rarified above, by the Sun-beams, is becomes lighter, and ſo bears leſs down the ſurface of the ſtagnant Mercury in the Ciſtern. But when the Air is nubilous and Cloudy, the weight of the Air,

is

is augmented, by the weight of the Clouds, which make it preſs with greater weight upon the ſtagnant Mercury in the Ciſtern.

I dare not oppoſe any thing to the Opinion, of ſuch an eminent man, tho I might, he being a hundred Stages beyond many. Yet there are not ſome wanting, who male-apartly ſet at nought his Philoſophical Syſtem, as inſufficient both for Matter, and Form; whereas among all the Learned Abroad, his Writings are held in great Eſtimation.

There is one of the Profeſſors of *Philoſophy* at *Aberdeen*, whoſe publick Theſes the laſt Year, came to my view: yet I ſhall adventure to ſay ſomething anent them. The Author, (whom I have not the favour to know) ſeems to be well acquaint with the new Philoſophy, and a good Schollar. He confutes rationally *Malebranch*, and *Spinoſa*, two wild Philoſophers. He ſeems to be a *Carteſian* in his Philoſophy, yet affirms that the Demonſtration (as he calls it) of God's Exiſtence, by the Idæa, being abſtract

abstract and Metaphysical, goeth far beyond the capacity of the Vulgar, and therefore being compell'd by Reason, he averreth, that the Apostle *Paul* reasons far better in the first to the *Romans*.

He speaks honourably of the late Lord President in confuting some of his Doctrine, for which he deserveth more thanks for his good Estimation of him, than for the strength of his Reasonings against him. He hopes the Lord *Stair*, will hold him excused, if he do not acquiesce to his Decisions. This seems to be jeastingly spoken. Casting my Eye further thorow, I found somewhat anent the Causes of Winds, Tempests, and Rain, and the reason why the Atmosphere, is sometimes lighter, and sometimes heavier. But he hath not touched the Nail upon the Head.

Some

Some Notes upon the Parisian Weather-Glass.

THere is a New Invention of a *Weather-Glass*, which cometh from *Paris* (*Jocale est inventis addere.*) set in a curious gilded Frame, more specious to behold, than profitable and useful. It is lyable to several Abatements. The first makes it a dumb Weather-Glass, wanting the whole Theory of the Weather, so that when a man looks to it, he knows not whether it shall be Fair or Foul. A man seeth indeed the sides of the Frame, divided by French Measure into Inches and half Inches; but these Measures have no signification of the Weather. When a man looks upon it in the Morning, he sees the Tinctured Liquor at such a hight; and in the Afternoon, he observes

observes again, and finds it higher or lower. This is all it signifieth. And if perhaps he be informed that in Fair Weather, the Liquor descends, and in Foul Weather it ascends, then he may conclude, observing it further down than it was, that it is probable to be Fair.

The second Abatement is, that there are two Oval-Glasses, which rather ought to be Cylindrical. Now unless there be a just and exact measure in hight, between the top of the one Oval-Glass, and the bottom of the other, it cannot be un-erring, or between the middle of the one, and the middle of the other. Because the Mercury cannot raise the Liquor in the right side, by equal portions, since the rising of it depends essentially upon the falling down of the Mercury from the left Oval-Glass. For the Glass being in form of a Pullets Egg, more Mercury falls down, whilst it is terminate about the middle, being there wider, than whilst the Mercury, is near either of the extreams;

treams, which are narrower. And I believe the Contriver hath foreseen this.

The third Abatement is, that the Tinctured Liquor is subject to Corruption, the Orifice of the Glass being open, suffering Evaporation, by which means, the whole Contrivance is rendred useless.

The fourth Abatement is, that the Orifice of the Glass, upon the left Hand, must be Hermetically Sealed, which few or none can do.

The fifth Abatement is, if it be once Mounted, and set a going, it cannot be well Dismounted, for the end which is Hermetically Sealed, must be opened, and cannot be well Sealed again.

Lastly, The Glass is brought Home from Abroad, not without hazard of breaking, the Glasses being very small and slender.

But there are none of these Difficulties found in the Perpendicular Glass. For it may be set up, and dismounted, as oft as you please, and transported from one place to another. And the excellency

excellency of it is, that it sets it self; for whatever weight of Mercury it once takes, the same will suffice it for ever. And which is marvellous, the Mercury falls down alway according to the Nature of the Weather, and there halts, whether it be Fair, or Foul.

There is a second sort of Weather-Glass much in use, called *the Sealed Weather-Glass*, whose use is only to shew the Heat and Coldness of the Air. It hath a round Glass below, about two Inch in Diameter, and a Stem going up from it, about a Foot and a half in length, but slender and narrow within. This Glass is filled with the finest *Spirit of Wine*, three or four times distilled, so in effect, being full of fiery Spirits, the least Heat or Warmness in the Air, rarifieth it, and the least Coldness contracteth it. When the Ball is once full, and the Stem too, the open Orifice above is Hermetically Sealed, and coming to the cold Air, from the warm place it was in, the Liquor creeps down towards the Ball, and by this means, it



demonstrats

demonſtrats by its creeping up the warmneſs of the Air, and by creeping down it ſhews the Degrees of Cold. It is Hermetically Sealed, that the outward Air may have no influence upon it. It is ſet in a curious gilded Frame, with the ſeveral Degrees of Heat and Cold affixed to it. They come from *Paris*, and *London*, not without hazard of breaking by the way.

There is a third ſort, ſpecially different from the reſt, called *the Water Weather-Glaſs*. It hath a round Head above, with a long Stem going down from it, and the Mouth below remaining open, is drowned among Tinctured Water. To ſet it a going, they uſe to warm the Head, and Body of it, at the Fire, and then to thruſt the open end among the Liquor in the Ciſtern. When the heat begins to abate in the top, the Air within, begins to contract it ſelf, and ſo the Water follows up, and hangs about the middle of the Stem. Thus in cold Weather creeps up, and in warm Weather creeps down. It creeps up for

fear

fear of Vacuity, as was maintained long ſince, before the preſſure of the Air was known by the *Torricellian Experiment*. This Weather-Glaſs was eſteemed infallible; but now it is known to be moſt fallacious, and uncertain. The reaſon is, becauſe it is acted and moved, not only with Heat and Cold, but with the greater and leſſer preſſure of the Air. If it be demanded, how ſhall I know, whether it be the coldneſs of the Air, or the greater preſſure of the Air, which cauſeth the Water to aſcend: and whether it be, the warmneſs of the Air, or the leſſer preſſure of the Air which cauſeth the Water to deſcend? I anſwer, It is difficult to know; for both do ſometime concur, that is, the weight and greater preſſure of the Air, and the coldneſs too. And ſometime the leſſer preſſure of the Air with warmneſs, make the Water fall down. And ſometime the greater preſſure of the Air raiſeth the Water, without any addition of Cold: And ſometimes the addition of Cold, without any alteration in the Air, as to

more

more weight, will raiſe it. And tho by this means it be fallacious, yet many notable Phenomena do appear from it. By the help of this, and the Mercurial-Weather-Glaſs, and the Sealed one, and by the help of the Hygroſcope, which marvellouſly ſhews the leaſt alteration in the Air, as to Moiſture and Dryneſs, and by contemplating the Heavens, the Sky and the Clouds, and conſidering the Winds, how they blow, and the various Aſpects of the Planets one to another, (as Star-gazers do affirm) men might come to foretell the Weather particularly.



The

The Theory of the Weather, according to the Mercurial Weather-Glass.

THE Theory of the Weather, is either Ingraven upon Braſs-Plates tichtly poliſhed, or upon a piece of Lombard-paper, wrought in the Taliduſe-preſs. The Braſs, or the Paper, is divided into Six half Inches; and every half Inch into Five Degrees; or every whole Inch into Ten equal parts. I call the upmoſt Station, *Long Fair*; the ſecond half an Inch under it, *Fair*: the third, *Changeable*: the fourth, *Rain*: the fifth, *Much Rain*: the ſixth, *Stormy*; and if you pleaſe to add the ſeventh, call it *Tempeſts*. Theſe ſix or ſeven, contain the whole Alterations, which uſe to be in the Weather. When the top of the Quickſilver

Quickſilver is at *Long Fair*, it toucheth exactly the Line under it. If it fall down, it is ſaid to be one Degree under *Long Fair*, or two or three, accordingly as it falls down, till the top be at the Line under *Fair*, and then it is Fair Weather, and ſo of the reſt of the Stations. It may be asked, At what hight, muſt *Long Fair* be affixed? I anſwer, The Situation of the place muſt be conſidered, and the Climat under which we live: for a Glaſs appropriated to this Parallel, will not ſerve in the Braes of *Athol*, or *Annandale*. And if there be not a juſt, and exact hight, to a Hairs breadth, of all the Stations from below, it cannot be un-erring. The ſeveral Stations are found out, not by Algebra, or any Mathematical Demonſtration, but by many years Obſervations. Whoſoever taketh upon him to mount a Weather-Glaſs, without the knowledge of theſe *Præcognita*, he plays but the Fool.

There are many other things neceſſary to be known, which every Fallow,

which hath no more in his Scull, but a Bag-pudding in ſtead of Brains, is not capable to underſtand.

I ſhall briefly run thorow the ſeveral Stations, with ſome Obſerves upon each one of them. In the firſt and upmoſt, is *Long Fair*, or moſt pleaſant Weather. I have ſeen the Quickſilver ſometimes above it, yet ſeldom doth this fall out, but in extraordinary Seaſons. The Mercury being at this hight, it is next to impoſſible, either to be Wind or Rain. Nothing for ſeveral Days, but ſettled calm Weather. Sometime the Heavens are covered with dry and gray Clouds, but not the leaſt appearance of Rain.

The ſecond Station, half an Inch lower, is *Fair*. The Mercury being here, I have obſerved a ſmall Showre of Rain to fall, from the loweſt Region of the Air, as a thick Dew or Miſt, but immediatly after, the Day became Clear and Fair. The whole year 1686 almoſt, it was a rare thing to ſee the Mercury up at *Fair*, but frequently below

Rain,

Rain, and *Changeable*, becauſe of the frequent Rains, which fell out that year. And which is obſervable, all that Summer, the Hygroſcope went not once about, whereas in dry Summers, it goeth twice about, ſometimes more and ſometimes leſs.

The third Station half an Inch lower, is *Changeable*. That is, ſometimes Fair, ſometimes Foul, ſometimes Froſt, ſometimes Thaw, ſometimes Sleet, and ſometimes Snow, ſometimes Wind, and ſometimes Calm.

The fourth Station is *Rain*, not actually Rain, but a ſtormy inclination in the Air to be Rain, and ſometimes Rain. Nay, ſometimes the whole Day will be Fair. But ſtill the Rain is approaching, or hath been Rain, either here, or ſome place about.

The fifth Station is *Much Rain*, the worſt of Weather almoſt, as in the Summer, or Winter Seaſon, when Rain is accompanied with ſtormy South-weſt Winds, or weſterly Winds. This laſt *October*, or *November*, I have ſeen the Mercury be-

low this Station, and yet no Rain in the mean time, nor all the Day, but the Sky black, and tempeſtuous, thick Clouds lying about the Horizon. Above *Fife*, great Heaps of them: ſome like Caſtles and Towers, others like ragged Rocks, hanging over each one another. All of them fore-runners of Rain.

The ſixth Station, *Stormy*, extraordinary Foul Weather.

In the laſt place, I have ſubjoyned *Tempeſts*, or *Hirricano's*, which do not fall out in this Countrey. If it be asked, Why doth not the Mercury fall down to *Tempeſts*? And why doth it not go half an Inch above *Long Fair*? I anſwer, There are here two Tropicks, namely *Storms*, the nethermoſt, and *Long Fair* the upmoſt. Above this, the Air is not able to preſs, except ſome few Degrees. And at *Storms* the preſſure is leaſt. The length of the Tropicks then, are about three Inch.

General Rules. The further the Mercury goeth up, the Weather inclines to be the Fairer, and the further it falls down,

down, it inclines to be the Fouler. Secondly, When the Mercury is higheſt, Fair Weather ſeems to be univerſal; when it is loweſt, Foul Weather ſeems to be univerſal. Thirdly, It is not ſo much Foul Weather actually, which influenceth the Mercury, as it is the Diſpoſition and Inclination of the Weather to be Foul: ſo that the Mercury will be many times at *Rain*, when it is not actually Raining, which is wanting when the Quickſilver, is at *Fair*, or *Long Fair*. Fourthly, Not only Foul Weather in this County or Shire, maketh the Mercury fall down, but Foul Weather, in the next adjacent County, tho there be none here: as the Weather-Glaſs at *Edinburgh*, will be altered, with Rain in *Tweeddale*, or in *Lammer-moor*. And as it ſhews the Nature of the Weather, ſo it predicts and foretells, ſometimes a Day, ſometimes two or three, if ſo be the Mercury hath been far up. But if it hath been only at *Changeable*, or below *Fair*, it predicts ſome few Hours, before it be Rain, by falling down, a

Degree, two or three, or four. When it is a falling down, the top of the Mercury is flat and level, but when it is a riſing, it is ſomewhat round.

'Tis ſaid, that the Ladies, and Gentlewomen at *London* do Apparel themſelves in the Morning by the Weather-Glaſs. Whatever be in this, 'tis certain, that when a man riſeth in the Morning, he may know infallibly, what ſort of Weather will fall out ere Night.

It is moſt uſeful for the Husband-man, both in Seed-time, and Harveſt, and for winning of Hay. It is uſeful for taking a Journey, for when I ſee the Mercury up at *Fair*, or *Long Fair*, I may be confident, there ſhall be no Rain for eight or ten Days, chiefly when it's up at *Long Fair*.

There are many other uſes, for which it is profitable, which are needleſs here to repeat. It is always infallible, becauſe guided by God in Nature, tho to our apprehenſion it ſeems to err. There are ſo many Changes, and Alterations in the Air, that a particular Rule cannot be

be assigned for each one of them. But the general Observations which are affixed, are sure. If any man would find out all these Intricacies, he must diligently observe, the Changes, and Quarters of the Moon, and the several Aspects of the Planets, and the Winds how they blow, comparing them with the Changes and Alterations of the Weather-Glass. Neither can it be subject to Corruption, tho it stand an hundred year. The Glass cannot fail, neither the Quicksilver, which are incorruptible by Nature. Neither can the Frame decay, for many years, being made of Oak.

FINIS.

Postscript.

To Buoy up a Ship, of any Burden, from the Ground of the Sea.

THE Art of Diving hath not been much known, but of late; for it depends essentially upon the knowledge of the pressure of Fluid Bodies, which knowledge hath not been further known to the generality of Learned Men, than by name: tho some ignorantly have averred, that the Hydrostaticks,

Hydroſtaticks, is a Science long ago perfected. Among the firſt, who have eſſayed in this Nation, was the late Marqueſs of *Argile*, who having obtained a Patent from the King, of one of the *Spaniſh Armado*, which was ſunk in the Iſle of *Mull*, *anno* 1588, employed *James Colquhoun* of *Glaſgow*, a man of ſingular knowledge, and skill, in all Mechanical Arts and Sciences. This man, not knowing the Diving-Bell, went down ſeveral times, the Air from above, being communicated to his Lungs, by a long Pipe of Leather. He only viewed, and ſurveyed the Ship, but I ſuppoſe buoy'd nothing up. About the year 1664, when this Art became more perfected, and was advanced, by the Practice, and Invention, of Learned Men. The late Lord *Argile* did employ a moſt ingenious Gentleman, the Laird of *Melgim*, who went down with a Diving Bell, and made a further inquiry. After ſome pains, and labour, he buoy'd up three Guns, one of Iron, judging it to be of ſome other Mettal, one of Copper, and one

one of Braſs, about eight Foot long a-peice, and eight Inches of Diameter. The third Eſſay was made by the late Earl of *Argile* himſelf, ſeveral years after, who did more. There was one Captain *Smith*, who undertook after that, yet more, who thought himſelf ſo ſure of the *Spaniſh* Gold, that he would not ſuffer a ~~Carpenter~~ with himſelf: but this Interprize turned to nought. To effectuate the Propoſal, I ſhall offer theſe ſix Propoſitions, which with ſmall pains may be made evident, from Hydroſtatical Principles; and next infer ſome Concluſions, needful for the deſign in hand.

Firſt, The whole Ship, with all its Loadning, is the juſt and preciſe weight, of as much Water, as the lower part of the Hull expells, or is expelled by the Ships Water-draught.

Secondly, When the Ship becomes heavier than the ſaid quantity of Water, it ſinks.

Thirdly, Water doth not weigh in Water. This is evident, for when a

man

man pulls a Bucket full of Water from the bottom of a Well, he finds no weight thereof, till it come to the Surface.

Fourthly, Nothing lighter in *ſpecie* than Water, or of the ſame weight with Water, can ſink. Hence, neither Timber, Wine, Bear, nor Oil, can tarry at the Sea Ground, but muſt be buoyed up of neceſſity.

Fifthly, By how much, the whole Timber of the Ship, is lighter in *ſpecie*, than as much Water equal to it in bulk, by ſo much is it the more able to buoy up. Imagine, the whole Timber of the Ship, reduced to a Cube of ſo many Foot, and a Cube of Water given of the ſame quantity. Now I ſay, as many Pounds, as this Cube of Water, is heavier, than that of Timber, ſo many Pounds of Iron, Lead or Stone, will the Ship buoy up, or ſupport, even tho full of Water.

Sixthly, A heavy Body, as Iron, Lead or Stone, weighs as much leſs in Water, than in Air, as the quantity of Water it expells. A Square Foot of Lead, which

I ſup-

I ſuppoſe weighs in the Air 728 Pound, weighs but 672 Pound in the Water, leſs by 56, the weight of a Square Foot of Water.

From theſe Propoſitions, I infer, that when a Ship is to be buoy'd up from the Ground of the Sea, nothing of her weighs, ſave her Ballaſt. By Ballaſt, I underſtand, taking the word largely, every thing in the Ship, heavier in *ſpecie*, than Water, as Guns, Ankers, Bullets of Iron, and Lead, Iron-bolts, Nails, and all manner of Iron-work. Next, That the whole weight of the Ballaſt, doth not preponderate or weigh down. Laſtly, That the Timber of the Ship, and all things in it, lighter in *ſpecie*, than Water, concur for buoying up the Ballaſt.

The beſt expedient for raiſing of Ships entirely, are Arks of Wood, applyed either to the ſides of the Ship without, or juſt above the Orlop. Theſe Arks muſt be ſo cloſe, on all ſides, that neither Air, nor Water, can paſs. The Ark, to deſcribe it more particularly,

muſt

man pulls a Bucket full of Water from the bottom of a Well, he finds no weight thereof, till it come to the Surface.

Fourthly, Nothing lighter in *ſpecie* than Water, or of the ſame weight with Water, can ſink. Hence, neither Timber, Wine, Bear, nor Oil, can tarry at the Sea Ground, but muſt be buoyed up of neceſſity.

Fifthly, By how much, the whole Timber of the Ship, is lighter in *ſpecie*, than as much Water equal to it in bulk, by ſo much is it the more able to buoy up. Imagine, the whole Timber of the Ship, reduced to a Cube of ſo many Foot, and a Cube of Water given of the ſame quantity. Now I ſay, as many Pounds, as this Cube of Water, is heavier, than that of Timber, ſo many Pounds of Iron, Lead or Stone, will the Ship buoy up, or ſupport, even tho full of Water.

Sixthly, A heavy Body, as Iron, Lead or Stone, weighs as much leſs in Water, than in Air, as the quantity of Water it expells. A Square Foot of Lead, which

I ſup-

I ſuppoſe weighs in the Air 728 Pound, weighs but 672 Pound in the Water, leſs by 56, the weight of a Square Foot of Water.

From theſe Propoſitions, I infer, that when a Ship is to be buoy'd up from the Ground of the Sea, nothing of her weighs, ſave her Ballaſt. By Ballaſt, I underſtand, taking the word largely, every thing in the Ship, heavier in *ſpecie*, than Water, as Guns, Ankers, Bullets of Iron, and Lead, Iron-bolts, Nails, and all manner of Iron-work. Next, That the whole weight of the Ballaſt, doth not preponderate or weigh down. Laſtly, That the Timber of the Ship, and all things in it, lighter in *ſpecie*, than Water, concur for buoying up the Ballaſt.

The beſt expedient for raiſing of Ships entirely, are Arks of Wood, applyed either to the ſides of the Ship without, or juſt above the Orlop. Theſe Arks muſt be ſo cloſe, on all ſides, that neither Air, nor Water, can paſs. The Ark, to deſcribe it more particularly,

muſt

muſt have four Sides, and a Cover above, but open compleatly below. At every Corner, next to the Mouth, muſt be fixed, a ſtrong Iron-Ring. Four likewiſe above, that is, one in each Corner, anſwering to the four below, which are for fixing a ſecond Ark above the firſt, if need be. If the Ship, which is to be raiſed, be twenty Foot over, make your Ark twenty Foot wide, and as much in hight. Bring it juſt over the place, where the Ship lyeth, and filling it with Water, that it may ſink without difficulty, thruſt it down, till it come juſt above the Orlop, and faſten it within five or ſix Foot of the ſame, with Ropes paſſing thorow the four Rings, and the Beams or Balks of the Ship. The Arks being thus faſtned to the Ship, by a Diver, the next work is to beget a power, or force within it, which ſhall be able to buoy up the Ship from the Ground of the Sea. This may be done, either by ſending down Buckets full of Air, with their Mouth foremoſt, one after another, from the Surface of the Water,

Water, and then cause a Diver receive them, and thrusting them somewhat within the Mouth of the Ark, turn up the Orifice, by which means, the whole Air in it, shall ascend up thorow the Water of the Ark, and rest above, next to the top. This Device being often repeated, will at last expell, the whole VVater of the Ark, and fill it compleatly with Air. This is so sure an Experiment, that none needs to call it in question. Or by communicating Air to the Ark from above, by the help of a pair of large Bellows, and long Pipes of Leather, going down within the Mouth of the Ark. Or thirdly, By the multiplication of Bladders full of VVind, filling the Ark within, which may be done more easily. The Ark being once full of Air, will have a considerable pull with it, which is more, and less, according to the dimensions thereof. For knowing this, you must consider, that whatever the dimensions of the Ark are, it will buoy up, as much weight as the VVater weighs, which fills it. If then, the Ark be twenty

ty Foot wide, and as much in hight, it muſt contain eight thouſand Square Foot of Water; and ſince every Square Foot of Water thereof weighs fifty ſix pound *Trois*, the whole muſt be 448000. An Ark then of twenty Foot Square, will buoy up, four hundred and fourty eight thouſand pound weight, the weight of 58 Cannons Royal, each one whereof, I ſuppoſe weighs 8000 pound. Or the weight of 74 Demi-cannons, or the weight of 97 Culverings: or of 149 Demi-culverings: or of 298 Sakers, each one of this ſort weighing 1500 pound. Or laſtly, the weight of 250 Tun of Wine, reckoning four Hogſheads to a Tun, and each one of theſe weighing 448 pound.

If you faſten a ſecond Ark above the firſt, by the help of the Rings upon the top, which I mentioned, both will buoy up together 896000 pound, the weight of 112 Cannons Royal. But if your Ark be 30 Foot in all its dimenſions, it muſt contain twenty and ſeven thouſand Square Foot of Water, which will

will weigh, one million, five hundred and twelve thouſand pound weight of the weight of 189 Cannons Royal, or the burden of 252 Demi-cannons, which is the weight of 844 Tun of Wine. But ſuppoſing the Ark to be more in quantity, the one way than the other, that is 40 Foot long, it ſhall be able to buoy up, two million and ſixteen thouſand pound, the weight of 252 Cannons Royal, or the weight of 1125 Tun of Wine, or Water.

If the Arks be applyed to the ſides of the Ship, you muſt fix, as many upon the one ſide, as upon the other, which need not be ſo large, as thoſe which are faſtned upon the Orlop. I ſhall ſuppoſe, that upon each ſide, there are four Arks, each one 10 Foot Square. If this be, every ſingle Ark, muſt contain 1000 Square Foot of Water, which will weigh fifty ſix thouſand pound. All of them together, therefore muſt buoy up 448000 pound weight, the burden of 56 Cannons Royal.

To know, how to proportion the

quantity of your Ark, to the burden of the Ship, which is the great ſecret, follow this Method. Conſider firſt, that neither the Timber of the Ship, nor the Water which is in her, nor any other thing, which is lighter in *ſpecie* than Water, (that is, any thing which floats upon the Surface) or of the ſame weight, with it, preponderats, or weighs down, but only what is heavier in *ſpecie*, than Water, as Guns, Ankers, Iron-bolts, Iron-nails, and ſuch like, the juſt quantity, or very near, may be found. Calculate then, as near as you can, and ſuppoſing the weight of all this Ballaſt, to be about 448000 pound; you muſt next conſider, what the dimenſions of the Ark, muſt be, which is able to buoy up ſo much weight, which may be found out thus. Divide the juſt account of your Ballaſt by 56, and the Cubique Root of the Product, gives you the juſt dimenſions of the Ark. For example, Divide 448000 by 56, and you will find 8000, the Cubique Root whereof is 20, the quantity of your Ark within.

If

If you judge it more convenient to apply leſſer Arks, namely to the ſides of the Ship, ye may have eight, by dividing this into ſo many parts, four for each ſide, and every ſingle Ark 10 Foot Square, which are equivalent. Remember, that tho the whole Ballaſt, weigh 448000 pound, yet this whole weight is not to be buoy'd up by the Ark, ſeing heavy Bodies weigh leſs in Water, than in Air, according to the ſixth Propoſition.

As for faſtening the Arks, either to the ſides of the Ship, or juſt above the Orlop, ſeveral ways may be thought upon, which I leave to the Invention of others, who are skilful in building of Ships. Let it ſuffice, that I have made it probable, if not evident with Reaſon, that the greateſt Ship may be buoy'd entirely up from the ground of the Sea, which was the thing to be demonſtrated.

If it be Objected, That the ſtrong preſſure of the Water, will put the Ark in hazard of burſting, when its full of

Air. I anſwer, There is here not ſo much hazard, as every one may believe. The Reaſon is, becauſe the preſſure within the Ark, is very near equal, to the preſſure from without. This I add, becauſe the top of the Ark within, is more preſt up by the Air within, than it is preſt down with the Water without. The preſſure upon the ſides, is more uniform, and ſo there is the leſs hazard there. In a word, if the Ark be able to ſupport, as much VVater, as fills it, without burſting, it ſhall go down thorow the deepeſt VVater imaginable without trouble. That is, hang it by Ropes in the Air, full of VVater. If the bottom be able to ſupport this weight, there ſhall be no hazard of burſting, when it's full of Air within the deepeſt VVater.

From this unequal preſſure, which the top of the Ark ſuffers, it follows of neceſſity, that if there be any Rift, or Leck in it, the whole Air will go out by degrees, and ſo render the Ark uſeleſs. I anſwer, this endeavour, which the

the Air within, hath to be out, is juſt the ſame, with that, which the VVater within, hath to be out, when the Ark is full, and hung in the Air with Ropes. If Art can cure the one, it may find a remedy for the other alſo. But I leave this to ſuch as are skilful in Calking of Ships.

Tho I ſeem to inſinuate, that the Arks muſt be Cubical or Fourſquare in their form, yet there is no neceſſity for that; for they may be made under what faſhion or form you pleaſe, provided they contain, as much Air as will be ſufficient to raiſe the Veſſel. And though I mention Arks of 20 or 30 Foot Square, which will go near to buoy up the greateſt Ships, as Men of VVar; yet for ordinary Veſſels, Arks of far leſs ſize will ſuffice.

Some may imagine, that a Ship ſunk (for example) with Coal, is as difficult to buoy up, as to raiſe her out of a dry Harbor. But this cannot be, ſince a pound of Coal, will not weigh three or four Ounce in the VVater. A Ship

loadned

[illegible]dned with VVine or Oyl, weighs nothing at all in the VVater, but may be very eaſily buoy'd up, if the Ballaſt be conſidered, as I ſaid. Many Ships have been buoy'd up entirely, by thruſting down empty Hogſheads, and putting them below the Deck. But here occurs a difficulty, if the Water exceed eight or nine Fathom, the ſtrong preſſure of it cruſheth the ſides of the Hogſhead together. But here is a ſoveraign cure againſt that trouble. Bore a ſmall Hole in any part of the Veſſel, where you pleaſe: for the Water entering, brings the Air within, to preſs equally with the Water without.

Tho this Invention, may ſeem difficult to ſome, to be made practicable, yet to ſuch who are intelligent, and know well the Principles of the Hydroſtaticks, it appears plain and eaſie. But the very Speculation of it wants not its own pleaſure, being founded upon infallible and ſure Concluſions, drawn from the ſureſt grounds in Nature.

Labor improbus omnia vincit.

Duo Bontà